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The following pages relate to the Model 154-4 Supplement to the Model 153/154 - 1 and 3 Programmable Pulse Generators.

The Model 154-4 digitally programmable pulse generator is designed for use in automatic systems for the testing of integrated circuits and other solid state devices. Front panel controls allow for use in conventional pulse generator laboratory applications. The instrument operates at repetition rates up to 50 MHz, delay and width up to 10 ms, transition times less than 5 ns and amplitudes up to 10 volts. All parameters, repetition rates, delay, width, upper and lower voltage levels (amplitude) pulse polarity and transition times can be controlled from a remote controller device via the IEEE STD-488 General Purpose Interface Bus (GPIB).

154-4 SUPPLEMENT

PULSE GENERATORS

1.18.3 IEEE STD-488 Interface (Model 154-4 Only)

Refer to IEEE STD-488 1975 for GPIB specifications and paragraph 3.3.3 of this supplement for the detailed operating instructions for the GPIB Interface.

2.20 IEEE-488 INTERFACE

Connector	24-pin metric dimensioned connector per IEEE STD-488 GPIB.
Address	5-rocker switches which allows selection of the Listen address assignments per IEEE STD-488.

3.3.3 IEEE STD-488 GPIB (Model 154-4)

The Model 154-4 Pulse Generator may be operated via the General Purpose Interface Bus (GPIB). The Pulse Generator can be controlled by, and talked to by, any device or devices that are IEEE STD-488 compatible.

The IEEE STD-488 GPIB system consists of a set of sixteen signal lines that are used to carry data information, interface messages and device dependent messages between different devices connected to the bus.

The GPIB is organized into three sets of signal lines:

1. Data bus, 8 signal lines (7 are actively used by the 154-4).
2. Data byte transfer control bus, 3 signal lines.
3. Interface management control bus, 5 signal lines (2 are actively used by the 154-4).

Figure 3-3 illustrates the GPIB structure and its interface capabilities.

NOTE

For complete details on the electrical, mechanical and timing requirements, refer to IEEE STD-488-1975.

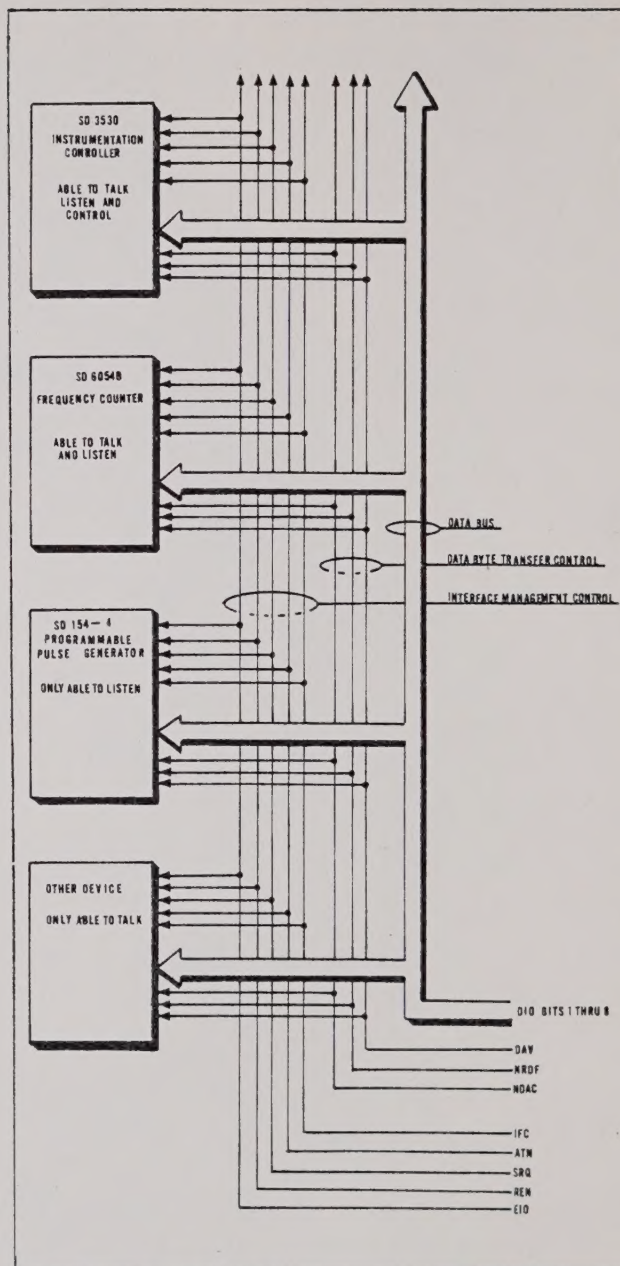


**FIGURE 3-3
GPIB INTERFACE CAPABILITIES
AND BUS STRUCTURE**

The bus interface lines are assigned IEEE-STD-488 mnemonics which are defined as follows:

DIO1 through DIO8: Data Input/Output lines 1 through 8, transmitted message bytes in bit parallel, byte serial format, asynchronously and in a bi-directional manner.

DAV: Data Valid, indicates the availability of data on the DIO lines.

NFRD: Not Ready For Data, indicates when the device is ready to accept data.

ATN: Attention, indicates how the data on the DIO lines is to be interpreted, and which devices will respond to the data.

IFC: Interface Clear, is used to set the interface system, and the devices connected to it into a known quiescent state.

NDAC: Data Not Accepted, indicates when the data received was accepted.

SRQ:* Service Request, is used to request service from a controller.

REN:* Remote Enable, is used by a controller device (in conjunction with other messages generated in the local logic) to place the Pulse Generator in the Remote Mode of operation.

EOI:* End Or Identify, is used to indicate the end of a data transfer or, with the ATN line to execute a polling sequence.

*These lines are not used by the Model 154-4 Pulse Generator, and are set in the tri state.

The 154-4 Pulse Generator may be on or off line as selected by the front panel MAN CONT switch. When the MAN CONT pushbutton switch is latched in the parameters can be controlled by the front panel controls. When the pushbutton switch is latched out, the parameters may be controlled by an instrumentation controller, a calculator or any other devices that are IEEE STD-488 compatible controllers. When power is applied to the Pulse Generator, it "wakes up" to the following conditions:

1. The Pulse Generator is placed in the Monitor Mode (unaddressed state).

2. All interim (input) and memory registers are set to zero.

TABLE 3-2 GPIB INTERFACE CONNECTOR

PIN NO.	IEEE STD-488 MNEMONIC	PIN NO.	IEEE STD-488 MNEMONIC
1	DIO1	13	DIO5
2	DIO2	14	DIO6
3	DIO3	15	DIO7
4	DIO4	16	DIO8(not used)
5	EIO(not used)	17	REN
6	DAV	18	GND(Return)
7	NFRD	19	GND(Return)
8	NDAC	20	GND(Return)
9	IFC	21	GND(Return)
10	SRQ(not used)	22	GND(Return)
11	ATN	23	GND(Return)
12	GND(Shield)	24	GND(Logic)

The "handshake" process functions as follows:

The IFC command is issued by the controller device and will cause the Pulse Generator to monitor the GPIB for further instructions. If the Pulse Generator was addressed as a listener, it will be unaddressed.

The addressing process is controlled by the GPIB ATN line and functions as follows:

1. The Pulse Generator is addressed to Listen by the controller issuing it's assigned Listen address while the ATN line is set active.
2. If the Pulse Generator was addressed to Listen, and the Unlisten (UNL) ASCII ? command is issued by the controller, the Pulse Generator will deselect as a listener.

The Listen address is selected by the Rear Panel 5-digit address switch. The setting of the 5-digit switch determines which Listen address will be

assigned to the Pulse Generator. Thirty-one Listen addresses may be assigned, refer to Table 3-3 for the address to ASCII Code format.

NOTE

A 1-1-1-1 address must not be assigned to any device interfacing the bus; these addresses are reserved for the unlisten ASCII (?).

TABLE 3-3
LISTEN ADDRESS ASSIGNMENTS
VS. ASCII CHARACTER

ADDRESS SWITCH SETTING BITS					ASCII CHARACTER
5	4	3	2	1	
0	0	0	0	0	SP
0	0	0	0	1	!
0	0	0	1	0	"
0	0	0	1	1	#
0	0	1	0	0	\$
0	0	1	0	1	%
0	0	1	1	0	&
0	0	1	1	1	,
0	1	0	0	0	(
0	1	0	0	1	)
0	1	0	1	0	*
0	1	0	1	1	+
0	1	1	0	0	,
0	1	1	0	1	-
0	1	1	1	0	.
0	1	1	1	1	/
1	0	0	0	0	0
1	0	0	0	1	1
1	0	0	1	0	2
1	0	0	1	1	3
1	0	1	0	0	4
1	0	1	0	1	5
1	0	1	1	0	6
1	0	1	1	1	7
1	1	0	0	0	8
1	1	0	0	1	9
1	1	0	1	0	:
1	1	1	1	1	;
1	1	1	0	0	<
1	1	1	0	1	=
1	1	1	1	0	>
⊕1	1	1	1	1	?

⊕Not to be device assigned. Refer to note.

The IEEE STD-488 Multiline Interface Messages relate to ASCII code. Table 3-4 provides the IEEE STD-488 DIO bit to ASCII code relationships.

TABLE 3-4
IEEE STD-488 DIO CODE
TO ASCII CHARACTER

IEEE STD-488 DIO BIT							ASCII CHARACTER
7	6	5	4	3	2	1	
0	1	0	0	0	0	0	SP
0	1	0	0	0	0	1	!
0	1	0	0	0	1	0	"
0	1	0	0	0	1	1	#
0	1	0	0	1	0	0	\$
0	1	0	0	1	0	1	%
0	1	0	0	1	1	0	&
0	1	0	0	1	1	1	,
0	1	0	1	0	0	0	(
0	1	0	1	0	0	1	)
0	1	0	1	0	1	0	*
0	1	0	1	0	1	1	+
0	1	0	1	1	0	0	,
0	1	0	1	1	0	1	-
0	1	0	1	1	1	0	.
0	1	0	1	1	1	1	/
0	1	1	0	0	0	0	0
0	1	1	0	0	0	1	1
0	1	1	0	0	1	0	2
0	1	1	0	0	1	1	3
0	1	1	0	0	0	0	4
0	1	1	0	1	0	0	5
0	1	1	0	1	1	0	6
0	1	1	0	1	1	1	7
0	1	1	1	0	0	0	8
0	1	1	1	0	0	1	9
0	1	1	1	0	1	0	:
0	1	1	1	0	1	1	;
0	1	1	1	1	0	0	<
0	1	1	1	1	0	1	=
0	1	1	1	1	1	0	>
0	1	1	1	1	1	1	?
1	0	0	0	0	0	0	@
1	0	0	0	0	0	1	A
1	0	0	0	0	1	0	B
1	0	0	0	0	1	1	C
1	0	0	0	1	0	0	D
1	0	0	0	1	0	1	E
1	0	0	0	1	1	0	F
1	0	0	0	1	1	1	G
1	0	0	1	0	0	0	H
1	0	0	1	0	0	1	I
1	0	0	1	0	1	0	J

TABLE 3-4
IEEE STD-488 DIO CODE
TO ASCII CHARACTER (Cont)

IEEE STD-488 DIO BIT							ASCII CHARACTER
7	6	5	4	3	2	1	
1	0	0	1	0	1	1	K
1	0	0	1	1	0	0	L
1	0	0	1	1	0	1	M
1	0	0	1	1	1	0	N
1	0	0	1	1	1	1	O
1	0	1	0	0	0	0	P
1	0	1	0	0	0	1	Q
1	0	1	0	0	1	0	R
1	0	1	0	0	1	1	S
1	0	1	0	1	0	0	T
1	0	1	0	1	0	1	U
1	0	1	0	1	1	0	V
1	0	1	0	1	1	1	W
1	0	1	1	0	0	0	X
1	0	1	1	0	0	1	Y
1	0	1	1	0	1	0	Z
1	0	1	1	0	1	1	[
1	0	1	1	1	0	0	\
1	0	1	1	1	0	1	]
1	0	1	1	1	1	0	^
1	0	1	1	1	1	1	—

The Pulse Generator can be programmed by sending device dependent messages during the Pulse Generator's Listen mode of operation. The Pulse Generator will ignore any device dependent or independent command for which it has not been designed or programmed to respond to.

Device dependent data is programmed into the Pulse Generator in 2 word serial groups, consisting of 3 serial bytes each. Each byte consists of 7 parallel bits.

The program format is in "Letter-Number-Number" bytes with two bytes to a word, where the Letter (Alpha) is the function word address and the numbers are two bytes of data, either range and MSD or SSD and LSD.

Three different message examples are provided to show the general format structure.

Example 1. To program the VUL to +2.50 volts an entry of A32B50 ASCII is programmed in the following sequence:

BYTE BITS	ASCII CHARACTER	FUNCTION
7 6 5 4 3 2 1		
1 0 0 0 0 0 1	A	VUL WORD A ADDRESS
0 1 1 0 0 1 1	3	+1 to +10V RANGE
0 1 1 0 0 1 0	2	MSD "2"
1 0 0 0 0 1 0	B	VUL WORD B ADDRESS
0 1 1 0 1 0 1	5	SSD "5"
0 1 1 0 0 0 0	0	LSD "0"

Example 2. To program the T- (FALL TIME) to 99.9 ns, an entry of G19H99 ASCII is programmed in the following sequence;

BYTE BITS	ASCII CHARACTER	FUNCTION
7 6 5 4 3 2 1		
1 0 0 0 1 1 1	G	FALL TIME WORD A ADDRESS
0 1 1 0 0 0 1	1	10 to 100 ns RANGE
0 1 1 1 0 0 1	9	MSD "9"
1 0 0 1 0 0 0	H	FALL TIME WORD B ADDRESS
0 1 1 1 0 0 1	9	SSD "9"
0 1 1 1 0 0 1	9	LSD "9"

Example 3. To program the REP RATE to 500 kHz, an entry of I35J00 ASCII is programmed in the following sequence;

BYTE BITS	ASCII CHARACTER	FUNCTION
7 6 5 4 3 2 1		
1 0 0 1 0 0 1	I	REP RATE WORD A ADDRESS
0 1 1 0 0 1 1	3	.1 to 1 MHz RANGE
0 1 1 0 1 0 1	5	MSD "5"
1 0 0 1 0 1 0	J	REP RATE WORD B ADDRESS
0 1 1 0 0 0 0	0	SSD "0"
0 1 1 0 0 0 0	0	LSD "0"

The word addresses are assigned ASCII Alpha Characters. Table 3-5 provides the ASCII Alpha and byte bit format for the 14 word addresses.

TABLE 3-5 WORD ADDRESS FORMAT

IEEE STD-488 PROGRAM BITS	ASCII CHARACTER	WORD ADDRESS
7 6 5 4 3 2 1		
1 0 0 0 0 0 1	A	VUL A
1 0 0 0 0 1 0	B	VUL B
1 0 0 0 0 1 1	C	VLL A
1 0 0 0 1 0 0	D	VLL B
1 0 0 0 1 0 1	E	RISETIME A
1 0 0 0 1 1 0	F	RISETIME B
1 0 0 0 1 1 1	G	FALLTIME A

TABLE 3-5
WORD ADDRESS FORMAT (Cont)

IEEE STD-488 PROGRAM BITS							ASCII CHARACTER	WORD ADDRESS
7	6	5	4	3	2	1		
1	0	0	1	0	0	0	H	FALLTIME B
1	0	0	1	0	0	1	I	REP RATE A
1	0	0	1	0	1	0	J	REP RATE B
1	0	0	1	0	1	1	K	DELAY A
1	0	0	1	1	0	0	L	DELAY B
1	0	0	1	1	0	1	M	WIDTH A
1	0	0	1	1	1	0	N	WIDTH B

The following tables 3-6 through 3-11 provide the ASCII numerical entered data for each word A 2nd Byte function(s).

TABLE 3-6
VUL WORD A FORMAT (ASCII A ADDRESS)

ASCII CHAR	FUNCTION(S)
0	-1V To -10V VUL RANGE
1	-.1V To -1V VUL RANGE
2	+1V To +1V VUL RANGE
3	+1V To +10V VUL RANGE
4	-1V To -10V VUL RANGE
5	-.1V To -1V VUL RANGE
6	+1V To +1V VUL RANGE
7	+1V To +10V VUL RANGE
8	EXT TRIG, -TRIG POL, -1V To -10V VUL RANGE
9	EXT TRIG, -TRIGPOL, -.1V To -1V VUL RANGE
:	EXT TRIG, -TRIG POL, +1V To +1V VUL RANGE
:	EXT TRIG, -TRIG POL, +1V To +10V VUL RANGE
<	EXT TRIG, +TRIG POL, -1V To -10V VUL RANGE
=	EXT TRIG, +TRIG POL, -.1V To -1V VUL RANGE
>	EXT TRIG, +TRIG POL, +1V To +1V VUL RANGE
?	EXT TRIG, +TRIG POL, +1V To +10V VUL RANGE

TABLE 3-7
VLL WORD A FORMAT (ASCII C ADDRESS)

ASCII CHAR	FUNCTION(S)
0	-1V To -10V VLL RANGE
1	-.1V To -1V VLL RANGE
2	+1V To +1V VLL RANGE
3	+1V To +10V VLL RANGE
4	COMPLEMENT, -1V To -10V VLL RANGE
5	COMPLEMENT, -.1V To -1V VLL RANGE
6	COMPLEMENT, +1V To +1V VLL RANGE
7	COMPLEMENT, +1V To 10V VLL RANGE
8	OUTPUT OFF, 1V To -10V VLL RANGE
9	OUTPUT OFF, -.1V To -10V VLL RANGE
:	OUTPUT OFF, +1V To +1V VLL RANGE

TABLE 3-7
VLL WORD A FORMAT (ASCII C ADDRESS) (Cont)

ASCII CHAR	FUNCTION(S)
:	OUTPUT OFF, +1V to 10V VLL RANGE
<	OUTPUT OFF, COMPLEMENT, -1 To -10V VLL
=	OUTPUT OFF, COMPLEMENT, -.1 To -1V VLL
>	OUTPUT OFF, COMPLEMENT, +1V To +1V VLL
?	OUTPUT OFF, COMPLEMENT, +1V To +10V VLL

TABLE 3-8
**RISE AND FALL TIME WORD A FORMAT
(ASCII E AND G ADDRESSES)**

ASCII CHAR	FUNCTION(S)
0	5 - 10 ns RISE TIME RANGE
1	10 - 100 ns RISE TIME RANGE
2	100 - 1000 ns RISE TIME RANGE
3	1 - 10 μ s RISE TIME RANGE
4	5 - 10 ns RISE TIME RANGE
5	10 - 100 ns RISE TIME RANGE
6	100 - 1000 ns RISE TIME RANGE
7	1 - 10 μ s RISE TIME RANGE
8	5 - 10 ns RISE TIME RANGE
9	10 - 100 ns RISE TIME RANGE
:	100 - 1000 ns RISE TIME RANGE
:	1 - 10 μ s RISE TIME RANGE
<	5 - 10 ns RISE TIME RANGE
=	10 - 100 ns RISE TIME RANGE
>	100 - 1000 ns RISE TIME RANGE
?	1 - 10 μ s RISE TIME RANGE

NOTE: Rise and Fall times recognize only Rise Time Ranges.

TABLE 3-9
REP RATE WORD A FORMAT (ASCII I ADDRESS)

ASCII CHAR	FUNCTION(S)
0	UNDEFINED
1	10 - 50 MHz REP RATE RANGE
2	1 - 10 MHz REP RATE RANGE
3	.1 - 1 MHz REP RATE RANGE
4	10 - 100 kHz REP RATE RANGE
5	1 - 10 kHz REP RATE RANGE
6	.1 - 1 kHz REP RATE RANGE
7	10 - 100 Hz REP RATE RANGE
8	UNDEFINED
9	SYNC GATING, 10 - 50 MHz REP RATE RANGE
:	SYNC GATING, 1 - 10 MHz REP RATE RANGE
:	SYNC GATING, .1 - 1 MHz REP RATE RANGE
<	SYNC GATING, 10 - 100 kHz REP RATE RANGE
=	SYNC GATING, 1 - 10 kHz REP RATE RANGE
>	SYNC GATING, .1 - 1 kHz REP RATE RANGE
?	SYNC GATING, 10 - 100 Hz REP RATE RANGE

TABLE 3-10
DELAY WORD A FORMAT (ASCII K ADDRESS)

ASCII CHAR	FUNCTION(S)
0	UNDEFINED
1	10 – 100 ns DELAY RANGE
2	.1 – 1 μ s DELAY RANGE
3	1 – 10 μ s DELAY RANGE
4	10 – 100 μ s DELAY RANGE
5	.1 – 1 ms DELAY RANGE
6	1 – 10 ms DELAY RANGE
7	UNDEFINED
8	UNDEFINED
9	DOUBLE PULSE, 10 – 100 ns DELAY RANGE
:	DOUBLE PULSE, .1 – 1 μ s DELAY RANGE
;	DOUBLE PULSE, 1 – 10 μ s DELAY RANGE
<	DOUBLE PULSE, 10 – 100 μ s DELAY RANGE
=	DOUBLE PULSE, .1 – 1 ms DELAY RANGE
>	DOUBLE PULSE, 1 – 10 ms DELAY RANGE
?	UNDEFINED

TABLE 3-11
WIDTH WORD A FORMAT (ASCII M ADDRESS)

ASCII CHAR	FUNCTION(S)
0	UNDEFINED
1	10 – 100 ns WIDTH RANGE
2	.1 – 1 μ s
3	1 – 10 μ s
4	10 – 100 μ s
5	.1 – 1 ms
6	1 – 10 ms
7	UNDEFINED
8	UNDEFINED
9	ASYNC GATING, 10 – 100 ns WIDTH RANGE
:	ASYNC GATING, .1 – 1 μ s WIDTH RANGE
;	ASYNC GATING, 1 – 10 μ s WIDTH RANGE
<	ASYNC GATING, 10 – 100 μ s WIDTH RANGE
=	ASYNC GATING, .1 – 1 ms WIDTH RANGE
>	ASYNC GATING, 1 – 10 ms WIDTH RANGE
?	UNDEFINED

The Model 154-4 Pulse Generator may be controlled by a calculator that is IEEE STD-488 compatible. Following is a typical example using the Hewlett Packard HP9825 calculator as a controller device.

The HP9825 calculator is connected to the 154-4 Pulse Generator via the GPIB cable. Then the calculator and Pulse Generator are programmed as to their addresses by the rear panel address switches (701 address is used in this typical example, 7 being the calculator bus address and 01 being the Pulse Generator's address in decimal.

The calculator printout shown in Figure 3-4 depicts the commands entered of the typical program.

```

0: wrt 701,"A32B500C10D0
50C10000E11F000
19H99I35J00K11L
00M24N00"iwait
1000
1: wrt 701,"C01D
25A31825E19F99G
11H00"iwait
1000
2: wrt 701,"I32J
50"iwait 1000
3: wrt 701,"M28H
00"iwait 1000
4: wrt 701,"E25F
00"iwait 1000
5: wrt 701,"G29H
00"iwait 1000
6: wrt 701,"E21F
00"iwait 1000
7: wrt 701,"G25H
00"iwait 1000
8: wrt 701,"E25F
00"iwait 1000
9: sto 0
*12415

```

FIGURE 3-4
TYPICAL HP9825 CALCULATOR PRINTOUT

Table 3-12 provides the step-by-step sequence of the typical program illustrated in Figure 3-4.

TABLE 3-12
TYPICAL PROGRAM HP9825

PROGRAM STEP	COMMAND	COMMENTS
0	Write ASCII "A32B500C10D0 0E11F00G19H99I35J00K11L 00M24N00" to program Pulse Generator parameters, and wait 1 second.	Programmed the Pulse Generator to the following para- meters; VUL +2.50V VUL + 000V RISE TIME 10 ns FALL TIME 99.9 ns

(Cont)

COMMENTS

The following program is entered via the Model 3530 keyboard and will be displayed on it's CRT Display. Figure 3-5 depicts the CRT display.

FIGURE 3-5 SD 3530 CRT DISPLAY
OF A TYPICAL PROGRAM

ASCII COMMAND
VUL to +2.50 V

This program will configure the 1544 Pulse Generator into the following operational parameters.

REP RATE 200 kHz (I32J00)
DELAY 10 ns (K11L00)
WIDTH 400 ns (M24N00)
VUL Alternates between +2.50 V
(A32B50) and +1.25V (A31B25)
VLL Alternates between 0V (C10D00)
and -1.25V (C01D25)
RISE TIME Alternates between 10 ns
(E11F00) and 99.9 ns (E19F99)
FALL TIME Alternates between 99.9 ns
(G19H99) and 10 ns (G11H00).

REPLACEABLE PARTS LIST

TITLE MODEL 154-4 IEEE INTERFACE PC ASSEMBLY						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
		ASSEMBLY, IEEE PC	52542	06710001	06710001	1
		PC BOARD	52542	067100	067100	1
	C1	CAPACITOR, Tant 22 μ F 10V	56289	196D226X9010JA1	103496	2
	C2	Same as C1				
	C3 thru C9	CAPACITOR, Cer .001 μ F 50V	71590	CW15C102M	100251	7
	C10	CAPACITOR, Cer .1 μ F 10V	71590	UK10-104	100120	2
	C11	Same as C10				
	C12	CAPACITOR, Mica 1000 pF 100V	72136	DM15FA102JO	10024301	2
	C13	Same as C12				
	CR1	DIODE	03508	1N4151	100385	2
	CR2	Same as CR1				
	R1	RESISTOR, CC 12k 1/4W 5%	01121	CB1235	101565	1
	R2	RESISTOR, CC 22k 1/4W 5%	01121	CB2235	101572	2
	R3	Same as R2				
	R4	RESISTOR, CC 1k 1/4W 5%	01121	CB1025	101569	1
	R5	RESISTOR, CC 1M 1/4W 5%	01121	CB1055	101605	2
	R6	Same as R5				
	R7	RESISTOR, CC 1.8k 1/4W 5%	01121	CB1825	101602	2
	R8	Same as R7				
	U1	RESISTOR Network 4 x 12k	52542	045008	045008	1
	U2 thru U5	RESISTOR Network 4 x 6.2k	52542	067116	067116	4
	U6 thru U9	RESISTOR Network 4 x 3k	52542	067115	067115	4
	U10	IC, TTL Quad Latch	01295	SN7475N	019710	2
	U11	Same as U10				
	U12	IC, TTL 4 - 16 line Decoder	01295	SN74154N	106640	1
	U13	IC, TTL Quad 2-In NAND	01295	SN7400N	019705	2

REPLACEABLE PARTS LIST

TITLE MODEL 154-4 IEEE INTERFACE PC ASSEMBLY (Cont)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	U14	IC, TTL Quad 2-In AND	01295	SN7408N	103093	2
	U15	IC, TTL Dual 4-In AND	01295	SN74LS21N	103970	1
	U16	IC, TTL Hex Inverter	01295	SN7404N	025779	1
	U17	IC, TTL 8-In NAND	01295	SN7430N	025726	1
	U18	IC, TTL 5-Bit Comp.	07263	93L24PC	117020	1
	U19	IC, TTL Hex Inverter Schmitt	01295	SN7414N	117078	2
	U20	Same as U19				
	U21 thru U24	IC, TTL Hex Inverter	01295	SN7416N	045230	4
	U25	IC, TTL Dual J-K Flip-Flop	01295	SN74S112N	025786	1
	U26	Same as U14				
	U27	IC, TTL Triple 3-In NAND	01295	SN7410N	019706	1
	U28	IC, TTL Quad 2-In OR	01295	SN7432N	045257	1
	U29	Same as U13				
	U30	IC, TTL Hex Buffer	01295	SN7417N	106629	1
	U31	IC, TTL Dual D Flip-Flop	01295	SN7474N	025241	1
	U32	IC, TTL Dual One-Shot MVB	01295	SN74123N	045209	1
	U33 thru U37	RESISTOR Network 4 x 1.8k	52542	067114	067114	5

INSTRUCTION MANUAL

MODEL 153/154-1 and 3
PROGRAMMABLE PULSE
GENERATORS

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FSCM No. 52542



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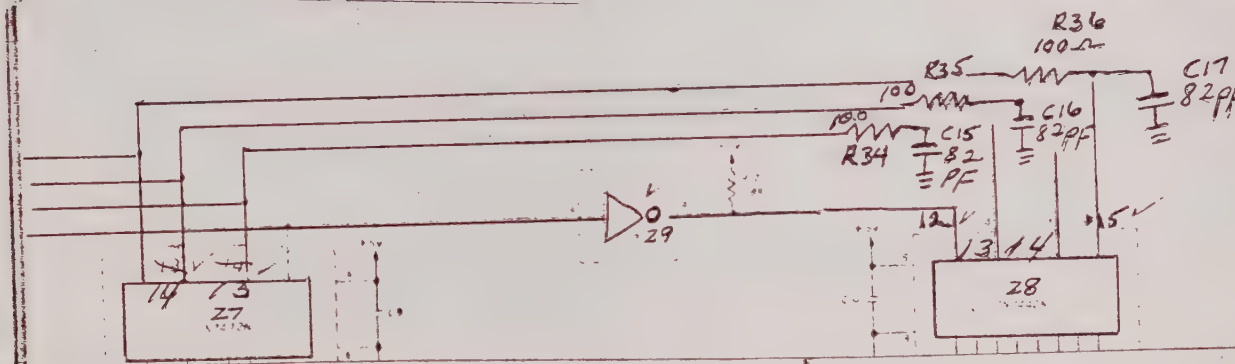
SYSTRON-DONNER CORP.
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ADDENDA AND ERRATA

MODEL 153/154-1 and 3

E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
4477	8-8-73	40000-483	Correct schematic as shown below. Z9 as inverter and Z7. Z8 pins assignment to conform with board layout. Add R34, R35, R36 resistors, 100 ohms and C15, C16, C17 capacitors, 82 pF on input lines of Z8, pins 13, 14 and 15.
			
4529	9-21-73	40000-417	Add fuse 1.5 amp, pig-tail type, P/N15470-100 in series from point N to lamps.
4556	10-18-73	40000-438	Change Q30 from DP59-0 to 2N2904A.
4713	4-9-74	40000-417	Change note 4 from All diodes are IRC 20A to All diodes are SC SS1m.



MODEL 153/154 PROGRAMMABLE PULSE GENERATORS

The Model 153/154 digitally programmable pulse generators are designed for use in automatic systems for the testing of integrated circuits and other solid state devices. Front panel controls on Model 153/154—1 allow for their use in conventional pulse generator laboratory applications. These instruments operate at repetition rates up to 50 MHz, delay and width up to 10 ms, transition times less than 5 ns and amplitudes up to 10 volts. All parameters, repetition rates, delay, width, upper and lower voltage levels (amplitude) pulse polarity and transition times (Model 154 only) can be controlled from a remote programming source.

TABLE OF CONTENTS

	PAGE
TITLE PAGE	i
FRONTISPIECE	iii
TABLE OF CONTENTS	v
LIST OF SCHEMATICS	vii
LIST OF FIGURES	vii
LIST OF TABLES	viii
 SECTION I	 SPECIFICATIONS
1.1	Repetition Rate 1-1
1.2	Delay 1-1
1.3	Width 1-1
1.4	Jitter 1-1
1.5	Upper Level (V_{UL}) and Lower Level (V_{LL}) 1-1
1.6	Transition Times (Model 154-1 and 3) 1-1
1.7	Waveform Aberrations 1-1
1.8	Accuracy 1-1
1.9	Output Protection 1-1
1.10	External Trigger Mode 1-1
1.11	Gate Modes 1-2
1.12	Double Pulse (Pulse Pairs) Mode 1-2
1.13	Output Complement Mode 1-2
1.14	Output Off 1-2
1.15	Trigger Output 1-2
1.16	Manual Control 1-2
1.17	External Programming 1-2
1.18	Programming Format 1-2
1.19	Programming Time 1-3
1.20	Operating Temperature 1-3
1.21	Power Required 1-3
1.22	Physical Characteristics 1-3
1.23	Accessories Furnished 1-3
1.24	Accessories Available 1-3
 SECTION II	 CONTROLS AND CONNECTORS
2.1	Power 2-1
2.2	Rep Rate 2-1
2.3	Delay 2-1
2.4	Rise (T_+)/Fall (T_-) (Model 154-1 and 3) 2-1
2.5	V_{UL} 2-1
2.6	V_{LL} 2-1
2.7	Man Cont 2-1
2.8	Sync Gate 2-1

SECTION II (cont)

PAGE

2.9	Async Gate	2-1
2.10	Ext Trig	2-1
2.11	Trig Polarity	2-5
2.12	Dbl PULse	2-5
2.13	Output Complement	2-5
2.14	Output Off	2-5
2.15	Output Connector	2-5
2.16	Trig Out Connector	2-5
2.17	Async Gate Connector	2-5
2.18	Sync Gate Connector	2-5
2.19	Ext Trig Connector	2-5
2.20	J1 and J2 Connectors	2-5
2.21	AC Power Connector	2-5
2.22	115/230 Volt Slide Switch	2-5

SECTION III OPERATING INSTRUCTIONS

3.1	General Instrutions	3-1
3.2	Manual Control Operation	3-1
3.3	Remote Programming Control	3-3

SECTION IV MAINTENANCE

4.1	Preventive Maintenance	4-1
4.2	Parts Replacement	4-1
4.3	Calibration	4-2
4.4	Specification Verification	4-13

SECTION V THEORY OF OPERATION

5.1	General Description	5-1
5.2	Detailed Circuit Description	5-1

SECTION VI PARTS LIST

6.1	Introduction	6-1
6.1.1	Reference Designations	6-1
6.2	Part Ordering Information	6-1
6.3	Parts Lists	6-1
	Front Panel Assembly	6-4
	Auxiliary Switch Assembly	6-5
	Front End PC Assembly	6-6
	IEEE Interface PC Assembly (Model 154-4 Only)	6-19
	VUL/VLL Control PC Assembly	6-22
	Variable Rise/Fall Power Supply (Model 154 Only)	6-27
	Variable Rise/Fall Output Amplifier PC Assembly (Model 154 Only)	6-31

MODEL 153/154—1 and 3

SECTION VI (cont)

PAGE

Circuit Board Assembly — Fixed Rise/Fall Output Amplifier (Model 153 Only)	6-38
150 Power Supplies and Regulator PC Assembly	6-43
Linear D/A Converter PC Assembly	6-47
Hyperbolic D/A Converter PC Assembly	6-50
Hyperbolic Conductance D/A Converter PC Assembly	6-55
Serial to Parallel Converter PC Assembly	6-58
Back Panel Assembly — 150 Series	6-60

LIST OF SCHEMATICS

Drawing Number	Title
41000-230	Block Diagram — Model 153/154 Programmable Pulse Generators
40000-421	Schematic — Front End
40000-558	Schematic — VUL/VLL Control Circuit
40000-551	Schematic — Variable Rise/Fall Power Supply II
40000-436	Schematic — Fixed Rise/Fall Output
40000-438	Schematic — Variable Rise/Fall Output Amplifier
40000-481	Schematic — Linear D/A Converter
40000-482	Schematic — Hyperbolic D/A Converter
40000-550	Schematic — Hyperbolic Conductance D/A Converter
40000-483	Schematic — Serial to Parallel Converter
40000-486	Schematic — Program Distribution Parallel Input Digital
40000-487	Schematic — Program Distribution Serial Input Digital
40000-417	Schematic — Power Supply

LIST OF FIGURES

Figure Number	Title	
2-1	Model 153/154 Controls and Connectors	2-2
2-2	Parallel Programming Information	2-3
2-3	Serial Programming Information	2-4
3-1	Parallel Input Sample Program	3-4
3-2	Output Waveform Sample Program	3-4
3-3	Serial Input Sample Program	3-6
4-1	Model 153/154 — Top View	4-3
4-2	Model 153/154 — Bottom View	4-4
4-3a	VUL/VLL Control Circuit Adjustments	4-5
4-3b	Rise/Fall Power Supply Adjustments	4-5
4-4	Linearity Characteristics	4-17
4-5	Pulse Characteristics	4-20
4-6a	Rep Rate Jitter	4-20
4-6b	Delay Jitter	4-20
4-6c	Width Jitter	4-20
5-1	Waveform Diagrams	5-2
5-2	Rep Rate Multivibrator	5-3

MODEL 154/153—1 and 3

LIST OF FIGURES (cont)

		PAGE
5-3	Delay One-Shot	5-6
5-4	VUL Range and Polarity Selection Circuit	5-9
5-5	Detailed Range and Polarity Selection Circuit	5-10
5-6	Simplified Block Diagram	5-11
5-7	Rise/Fall Output Amplifier Circuit	5-15
5-8	Hyperbolic D/A Converter	5-16

LIST OF TABLES

4-1	Repetition Rate Checks	4-14
4-2	Delay/Width Checks	4-14
4-3	VUL/VLL Range Checks	4-16
4-4	Rise (T_+)/ Fall (T_-) Time Checks	4-18
6-1	Manufacturer's Code-To-Name Index	6-2

SECTION I

SPECIFICATIONS

1.1 REPETITION RATE

Variable from 10 Hz to 50 MHz in seven ranges. In the double pulse mode the repetition rate is limited to 25 MHz maximum.

1.2 DELAY

Variable from 10 ns to 10 ms in six ranges. Maximum duty factor is 70% for repetition rates below 10 MHz and 50% for repetition rates above 10 MHz. In the double pulse mode, minimum separation between pulses (measured between the trailing edge of the first pulse and the leading edge of the second pulse) must be greater than 30% of the pulse width or 20 ns, whichever is greater.

1.3 WIDTH

Variable from 10 ns to 10 ms in six ranges. Maximum duty factor is 70% for repetition rates below 10 MHz and 50% for repetition rates above 10 MHz. Duty factors to 100% may be achieved through the use of the complement mode.

1.4 JITTER

Repetition Rate, Delay and Width jitter are <0.05% or 200 ps whichever is greater.

1.5 UPPER LEVEL (V_{UL}) and LOWER LEVEL (V_{LL})

Independently variable between -10 V and +10 V at amplitudes between 1.0 V and 10.0 V. Maximum difference between upper and lower level settings is limited to 10 V.

1.6 TRANSITION TIMES (Model 154—1 and 3)

1.6.1 Variable Transition Times (Model 154 only)

T_+ (positive-going transition time) and T_- (negative-going transition time) are variable from <5 ns to 10 μ s in four ranges and are independently variable within the same range. Linearity is $\pm 5\%$ above 10 ns and $\pm 10\%$ below 10 ns.

1.6.2 Fixed Transition Times (Model 153 only)

T_+ and T_- are fixed at <5 ns.

1.7 WAVEFORM ABERRATIONS

Less than 5% of waveform excursion when output is terminated with 50 ohms.

1.8 ACCURACY

Accuracy is $\pm 5\%$ +1 ns of programmed value for all timing parameters and $\pm 5\%$ of programmed value for V_{UL} and V_{LL} >1 volt at 25° C. Accuracy is valid for BCD or thumbwheel settings between 100 and 999 only.

1.9 OUTPUT PROTECTION

The output is fully protected against damage from open circuit, short circuit to ground, programming errors and external voltages less than ± 10 V.

1.10 EXTERNAL TRIGGER MODE

In this mode, the instrument can be triggered by an external source at repetition rates up to

50 MHz. The external trigger can be a positive or negative pulse but must have a minimum width of 4.5 ns and minimum amplitude of 1 volt. Input impedance is 50 ohms. The maximum level that can be safely applied is ± 5 V.

1.11 GATE MODES

A +1 volt pulse is required to enable either synchronous or asynchronous gating. Input impedance is 50 ohms. The maximum level that can be safely applied is ± 5 V.

1.11.1 Synchronous Gate Mode

In this mode, the output occurs only for the time interval of an externally applied gate pulse. The rep rate multivibrator is enabled by the gate pulse, therefore the output and the gate pulse are synchronized.

1.11.2 Asynchronous Gate Mode

In this mode, the output occurs only for the time interval of an externally applied gate pulse. The rep rate multivibrator is operating continuously in this mode, therefore the output and the gate pulse are not synchronized.

1.12 DOUBLE PULSE (Pulse Pairs) MODE

Two pulses per repetition rate period are generated at the output. The first pulse is coincident with the trigger output, the position of the second pulse is determined by the delay setting.

1.13 OUTPUT COMPLEMENT MODE

In this mode, the time positions of upper (V_{UL}) and lower (V_{LL}) levels are reversed. T_+ and T_- are also reversed in the Model 154 instruments.

1.14 OUTPUT OFF

In this mode, the output levels are at ground, however, the trigger output is uninterrupted.

1.15 TRIGGER OUTPUT

A positive pulse with a minimum amplitude of 1.2 volts, minimum width of 5 ns and a maximum T_+ of 3 ns when terminated with 50 ohms.

1.16 MANUAL CONTROL

Front panel thumbwheels and pushbuttons are provided for the control of all pulse parameters and modes of operation. T_+ (rise time) and T_- (fall time) are not variable on Model 153 instruments.

1.17 EXTERNAL PROGRAMMING

All pulse parameters (with the exception of T_+ and T_- on the Model 153—1 and 3) and modes of operation can be controlled from an external programming source. The logic levels for ground true instruments are 0 V for true (logical 1) and +5 V for false (logical 0). For positive true instruments +5 V is true (logical 1) and 0 V is false (logical 0).

1.18 PROGRAMMING FORMAT

No provision is made for synchronous programming of the timing parameters of this instrument. Therefore, the apparent programming time may be as long as the programming time (above) plus the sum of the period from which the program was changed and the period to which it is changed. If synchronous programming is desired, it may be accomplished by synchronizing the programming source to the sync pulse out of the generator.

1.18.1 Parallel Input (Model 153/154—1)

Format is BCD (8 - 4 - 2 - 1) ground true or positive true logic. Compatible with TTL and DTL logic. Eighty programming lines are required for Model 153 and 106 lines are required for Model 154. A true input enables the mode of operation (EXT TRIGGER, SYNC GATE, etc.) and range or vernier BCD bits.

SECTION II

CONTROLS AND CONNECTORS

Refer to Figure 2 - 1 for the following description of controls and connectors. For external programming information for instruments with parallel inputs, refer to Figure 2 - 2. For external programming information for instruments with serial inputs, refer to Figure 2-3.

2.1 POWER

Turns the instrument off and on and illuminates the indicator lamp.

2.2 REP RATE

The thumbwheel on the right selects one of seven available repetition rate ranges and the three remaining thumbwheels continuously vary the repetition rate within the range selected.

2.3 DELAY

The thumbwheel on the right selects one of six available delay ranges and the three remaining thumbwheels continuously vary the delay within the range selected.

2.4 RISE (T_+)/FALL (T_-) (Model 154—1 and 3)

The middle thumbwheel selects one of four available T_+ (positive-going transition time) and T_- (negative-going transition time) ranges. The three thumbwheels to the left of the range selector continuously vary T_+ within the range selected and three thumbwheels to the right of the range selector continuously vary T_- within the range selected.

2.5 V_{UL}

The thumbwheel on the right selects one of four available upper level voltage ranges and the

three remaining thumbwheels continuously vary the voltage level within the range selected.

2.6 V_{LL}

The thumbwheel on the right selects one of four available lower level voltage ranges and the three remaining thumbwheels continuously vary the voltage level within the range selected.

2.7 MAN CONT

Selects the method of controlling the output pulse parameters. When the pushbutton is depressed, the parameters can be controlled by the front panel controls. When the pushbutton is released, the parameters can be controlled by an external programming source.

NOTE: The MAN CONT pushbutton must always be in the released position when an external programming source is connected, otherwise erroneous programs will result.

2.8 SYNC GATE

Enables synchronous gating when the pushbutton is depressed.

2.9 ASYNC GATE

Enables asynchronous gating when the pushbutton is depressed.

2.10 EXT TRIG

Selects the external trigger mode when the pushbutton is depressed.

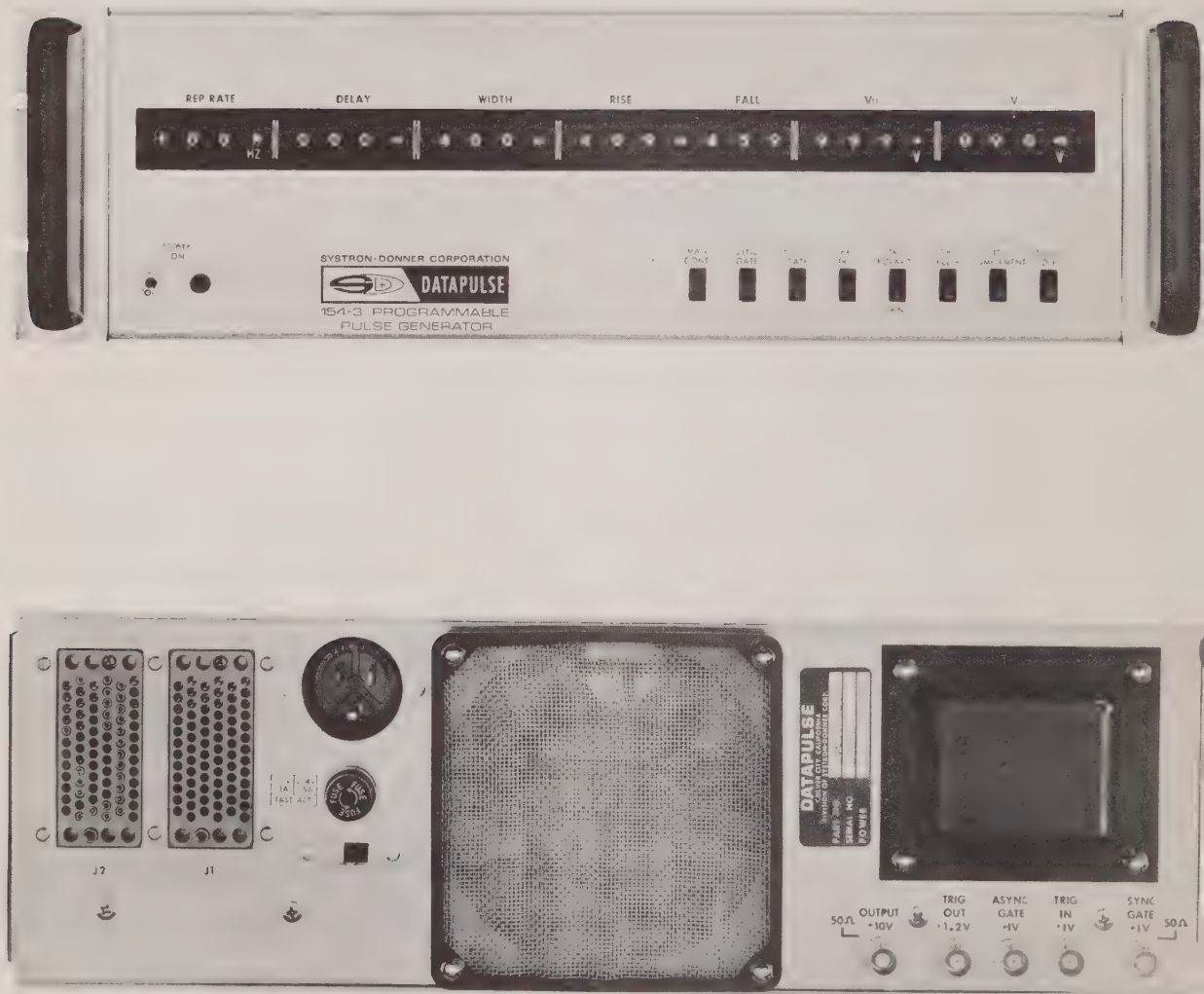
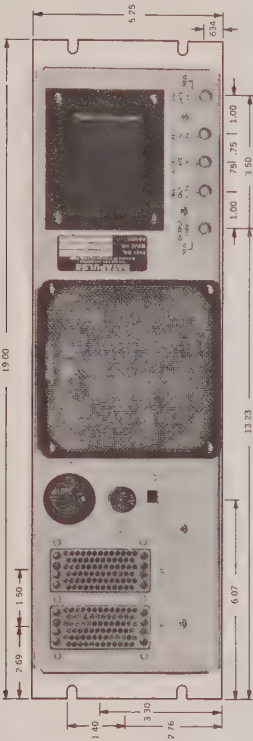


Figure 2-1. Model 153/154 Controls and Connectors

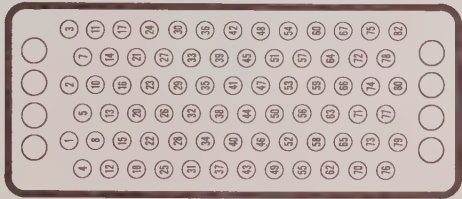


CONNECTOR LOCATION

PIN ASSIGNMENTS

#	RNG	REP RATE	DELAY OR WIDTH	V_{in} OR V_{in}	T_r & T_f	BCD
0				-1 V to -10 V	5 ns to 10 ns	1 2 4
1		10 MHz to 50 MHz	10 ns to 100 ns	-0.1 V to -1 V	10 ns to 100 ns	0 0 0
2		1 MHz to 10 MHz	0.1 μ s to 1 μ s	+0.1 V to +1 V	0.1 μ s to 1 μ s	1 0 0
3		0.1 MHz to 1 MHz	1 μ s to 10 μ s	+1 V to +10 V	1 μ s to 10 μ s	0 1 0
4		10 KHz to 100 KHz	10 μ s to 100 μ s	V_{in} &/or V_{in} may each be set to 0 V (ground)		1 1 0
5		1 KHz to 10 KHz	0.1 ms to 1 ms			0 0 1
6		0.1 KHz to 1 KHz	1 ms to 10 ms			0 1 1
7		10 Hz to 100 Hz				1 1 1

RANGE CODING



J1 & J2

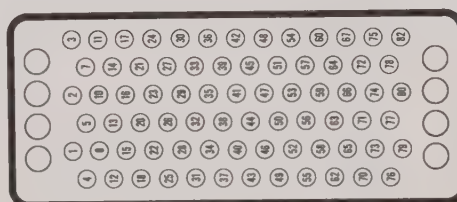
Winchester Type
MRAC75S-J with
type 100-1020S
removable pins
(facing rear panel)

PROGRAM FORMAT BY	RANGE	VERNIER SIGNIFICANT DIGITS
PIN ASSIGNMENT	1 2 4	MOST 1 2 4 8 1 2 4 8 1 2 4 8
PROC. PARAMETER		
EXT. TRIGGER	1	
REP RATE		
+ TRIG POLARITY		
DELAY		
SYNC GATE		
WIDTH		
ASYNC GATE		
V_{in}		
PULSE PAIRS		
V_{in}		
COMPLEMENT		
T_r		
T_f		
OUTPUT OFF		
SPECIAL PIN ASSIGNMENTS J1-80 and J2-80 chassis ground		
LOGIC LEVELS: +5V true or ground true; customer option		
NOTE: T_r and T_f are variable only on Models 154 and 154-1		

Figure 2 - 2. Parallel Programming Information

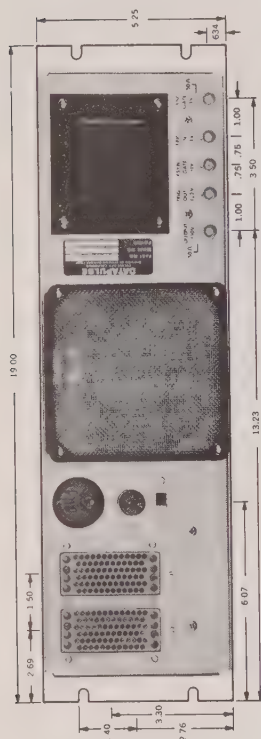
No.	REP RATE	DELAY OR WIDTH	V_{in} OR V_{in}	T_r & T_f	BCD		
					1	2	4
0			-1 V to -10 V	5 ns to 10 ns	0	0	
1	10 KHz to 50 KHz	10 ns to 100 ns	-0.1 V to -1 V	10 ns to 100 ns	1	0	
2	1 MHz to 10 MHz	0.1 μ s to 1 μ s	+0.1 V to +1 V	0.1 μ s to 1 μ s	0	1	
3	0.1 MHz to 1 MHz	1 μ s to 10 μ s	+1 V to +10 V	1 μ s to 10 μ s	1	1	
4	10 KHz to 100 KHz	10 μ s to 100 μ s			0	1	
5	1 KHz to 10 KHz	0.1 ms to 1 ms			0	1	
6	0.1 MHz to 1 KHz	1 ms to 10 ms			0	1	
7	10 Hz to 100 Hz				1	1	

RANGE CODING



J1 & J2

CONNECTOR LOCATION



PROGRAM FORMAT	PIN #J1:	ADDRESS				DATA BITS								
		"0"	"1"	"2"	"3"	1	2	3	4	5	6	7	8	
REP RATE	A	1	0	0	1	sync gate	range "4"	range "2"	range "1"	22	28	34	40	46
	B	1	0	1	0	80	40	20	10	8	4	2	1	
DELAY	A	1	0	1	1	pulse pairs	range "4"	range "2"	range "1"	22	28	34	40	46
	B	1	1	0	0	80	40	20	10	8	4	2	1	
WIDTH	A	1	1	0	1	async gate	range "4"	range "2"	range "1"	22	28	34	40	46
	B	1	1	1	0	80	40	20	10	8	4	2	1	
V _{as}	A	0	0	0	1	ext trig	+ trig poll	range "2"	range "1"	22	28	34	40	46
	B	0	0	1	0	80	40	20	10	8	4	2	1	
V _{ls}	A	0	0	1	1	output off	complete ment	range "2"	range "1"	22	28	34	40	46
	B	0	1	0	0	80	40	20	10	8	4	2	1	
T _s	A	0	1	0	1			range "2"	range "1"	22	28	34	40	46
	B	0	1	1	0	80	40	20	10	8	4	2	1	
T _e	A	0	1	1	1									
	B	1	0	0	0	80	40	20	10	8	4	2	1	

SPECIAL PIN ASSIGNMENTS: J1-31, Address Clock; J1-37, Delayed Clock out; J1-80 Chassis Ground.

LOGIC LEVELS: +5V true or ground true; customer option.

NOTE: T_s and T_r are variable on Models 154.

MODEL 153/154-2 and 3

Figure 2-3. Serial Programming Information

2.11 TRIG POLARITY

Selects the trigger polarity for the external trigger mode. When the pushbutton is depressed triggering with positive pulses is enabled. When the pushbutton is released triggering with negative pulses is enabled.

2.12 DBL PULSE

Selects the double pulse (pulse pairs) mode when the pushbutton is depressed.

2.13 OUTPUT COMPLEMENT

Reverses the time positions of the upper level (V_{UL}) and lower level (V_{LL}) voltages when the pushbutton is depressed. The time position of T_+ and T_- are also reversed.

2.14 OUTPUT OFF

Turns off the output pulse when the pushbutton is depressed (trigger output is interrupted).

2.15 OUTPUT Connector

Output connector for the main pulse.

2.16 TRIG OUT Connector

Output connector for the trigger pulse.

2.17 ASYNC GATE Connector

Input connector for an asynchronous gate signal. Impedance is 50 ohms.

2.18 SYNC GATE Connector

Input connector for a synchronous gate signal. Impedance is 50 ohms.

2.19 EXT TRIG Connector

Input connector for an external trigger source. Impedance is 50 ohms.

2.20 J1 and J2 Connectors

Input connectors for the external programming source.

NOTE: Refer to Figure 2-2 for all programming information for parallel instruments. Refer to Figure 2-3 for all programming information for serial instruments.

2.21 AC POWER Connector

Input connector for an ac power source.

2.22 115/230 VOLT SLIDE Switch

Selects the transformer primary configuration for either 115 or 230 volts.

SECTION III

OPERATING INSTRUCTIONS

3.1 GENERAL INSTRUCTIONS

CAUTION

When re-installing D/A cards check carefully to ensure that card is being installed in appropriate connector; all D/A cards have the same polarizing key slots.

The Model 153/154 instruments are fully protected and no combinations of front panel settings, misprogramming, short circuit or external voltage less than 10 volts will cause damage. Refer to Section II for the function of all controls and connectors and for all remote programming information. The ac power connector, fuse and line voltage switch (115/230 V slide switch) are located on the back panel. The proper size fuse is 3.0 amp slow-blow for 115 V and 1.5 amp slow-blow for 230 V operation. Always make sure that the line voltage switch agrees with the power source before connecting the power connector.

3.1.1 Duty Factor Limitation

Duty factor is defined as the ratio of the pulse duration or delay to the duration of the total repetition rate period. Therefore the percentage duty factor is calculated by the following equation:

$$\% \text{duty factor} = \frac{\text{Pulse width or delay} \times 100}{\text{—rep rate period}}$$

For example, if the repetition rate is set at 1 MHz and the pulse width or delay is $0.5 \mu\text{s}$, the duty factor is:

$$\% \text{duty factor} = \frac{0.5 \times 10^6 \times 100}{1 \times 10^6} = 50\%$$

The same duty factor limitations apply for external and internal trigger operation. The limits are 70% for repetition rates below 10 MHz, 50% for repetition rates above 10 MHz.

3.1.2 Double Pulse Minimum Separation

In the double pulse mode, the delay control sets the separation between the two pulses. For proper operation without affecting the pulse shape there are minimum separation limits.

Separation is measured between the trailing edge of the first pulse and the leading edge of the second. Minimum double pulse separation must be greater than 30% of the pulse width or 20 ns, whichever is greater. For example if the width is $0.1 \mu\text{s}$, the minimum pulse separation should be:

$$\text{minimum separation} = (0.1 \times 10^6) \times (30\%) = 30 \text{ ns}$$

3.1.3 Output Termination

When the instrument is not operating into a 50 ohm load, it must be terminated with 50 ohms at the load under test. A 5 watt termination is recommended, however a 2 watt termination is adequate for most operating conditions. Care should be exercised if a 2 watt termination is used when the instrument is in the complement mode since the maximum power out is 2 watts.

Fifty ohm coaxial cables should be used to connect the instrument to the load. Minimum cable length should be used to prevent deterioration of the pulse quality.

3.2 MANUAL CONTROL OPERATION

When the MAN CONT pushbutton is depressed the output pulse parameters can be controlled by the front panel switches.

3.2.1 External Trigger Mode

With the EXT TRIG switch depressed, an external trigger signal from 10 Hz to 50 MHz with a ± 1 V to ± 5 V amplitude will generate pulses in the instrument. To operate the instrument in the external trigger mode, proceed as follows:

- a. Depress the MAN CONT pushbutton.
- b. Depress the EXT TRIG pushbutton and connect the external trigger source to the TRIG IN connector.
- c. Select positive or negative trigger polarity by depressing the TRIG POLARITY pushbutton for a positive trigger or releasing it for a negative trigger.
- d. Select the DELAY and WIDTH ranges and set the thumbwheels for the desired width and delay. Refer to paragraph 3.1.1 for duty factor limitations.
- e. If synchronization is required, connect the TRIG OUT to the external circuit.
- f. Select the V_{UL} and V_{LL} ranges and set the thumbwheels for the desired amplitude. The difference between V_{UL} and V_{LL} should not exceed 10 volts. Terminate the OUTPUT with 50 ohms if the load is not 50 ohms.
- g. (Model 154 instruments only.) Select the RISE/FALL range and adjust the rise (T_+) and fall (T_-) thumbwheels to the desired setting. Each transition time is independently variable.

- h. If a negative-going pulse is desired, depress the OUTPUT COMPLEMENT pushbutton.
- i. If the double pulse mode is desired, depress the DBL PULSE pushbutton. Observe the minimum spacing limitation described in paragraph 3.1.2.

3.2.2 Internal Trigger Mode

When the EXT TRIG pushbutton is released the instrument will generate pulses at the rate set by the REP RATE controls. The repetition rate is variable from 10 Hz to 50 MHz. To operate the instrument in the internal trigger mode proceed as follows:

- a. Release the EXT TRIG pushbutton.
- b. Select the REP RATE range and set the thumbwheels for the desired repetition rate.
- c. Perform steps (d) through (i) of paragraph 3.2.1.

3.2.3 Gate Mode

When the SYNC GATE or ASYNC GATE pushbutton is depressed, the output of the instrument will occur for the duration of a +1 V to +5 V pulse applied at the SYNC GATE or ASYNC GATE input. In the SYNC GATE mode the output pulse is synchronized to the gate signal. In the ASYNC GATE mode, the output pulse is not synchronized to the gate signal. To operate the instrument in the SYNC GATE mode proceed as follows:

- a. Depress the SYNC GATE pushbutton and connect the gate signal to the SYNC GATE input. Set the amplitude of the gate signal for at least +1 volt (but less than +5 volts). Select the REP RATE range and set the thumbwheels for the desired repetition rate.

- b. Set the remaining controls the same as in steps (d) through (i) of paragraph 3.2.1.
- c. Connect the OUTPUT connector to the load. The gated output will be synchronized to the gate signal.
- d. For asynchronous gating, depress the ASYNC GATE pushbutton and connect the gate signal to the ASYNC GATE input. Set the amplitude of the gate signal for at least +1 volt.
- e. Set the instrument controls the same as in steps (d) through (i) of paragraph 3.2.1.
- f. Connect the OUTPUT connector to the load. The gated output is synchronized to the gate signal.

3.3 REMOTE PROGRAMMING CONTROL

3.3.1 Parallel Input (Model 153/154—1 and 3)

Parameter range selection is accomplished by a 2 or 3 digit BCD input and vernier control within each range is accomplished by a 12-bit (3 digit; maximum setting 999) BCD inputs. A total of 80 lines are required to fully program the Model 153 and 106 lines are required to fully program the Model 154. A logical one (1) or a true input enables the mode of operation (EXT TRIGGER, +TRIG POLARITY, SYNC GATE, ASYNC GATE, PULSE PAIRS, COMPLEMENT and OUTPUT OFF) or the range or vernier BCD bit. A logical zero (0) or false input disables them. For a positive true instrument all bits that are open circuited will be enabled, therefore if it is desired that a bit be disabled, it must be grounded.

Programming time for all parameters is 100 μ s with the exception of V_{UL} and V_{LL} , which have a programming time of 3 ms. Parameters may

be programmed in any order, however, since programming time for V_{UL} and V_{LL} is longer, it is good practice to program them first. Refer to Figure 2 - 2 for the connector pin assignment for the range and vernier bits and mode selection. Refer to the range coding chart for all parameter range numbers.

3.3.1.1 Sample Program

Figure 3 - 1 shows a sample program. A thorough study and a performance of the program will demonstrate how the instrument is operated. Refer to Figure 2 - 2 for the connector pin assignments for mode selection and range and vernier bits. See range coding charts for range numbers. If the instrument is properly programmed the output should have the characteristics of the pulse displayed in Figure 3 - 2.

3.3.1.2 External Trigger Mode

When the instrument is in the EXTERNAL TRIGGER mode, an external trigger signal from 10 Hz to 50 MHz with a ± 1 V to ± 5 V amplitude will generate pulse in the instrument. To operate the instrument in the external trigger mode proceed as follows:

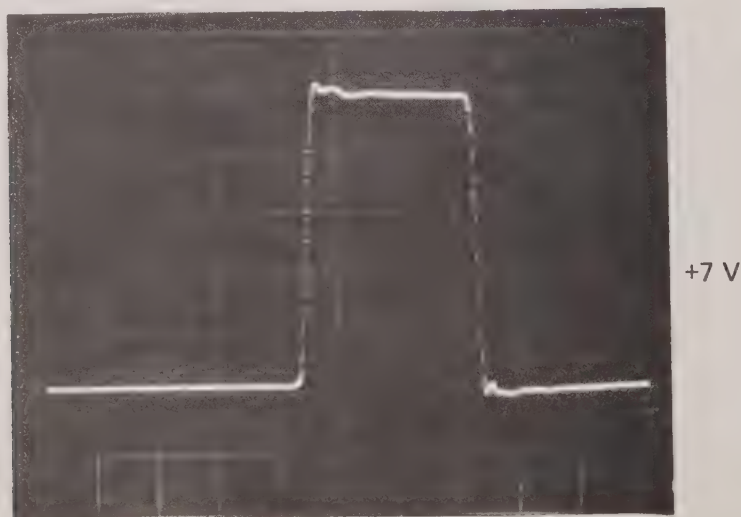
- a. Connect the programming source to connectors J1 and J2.
- b. Connect an external trigger source to TRIG IN connector. Set the trigger source for the desired trigger level (± 1 V minimum, ± 5 V maximum) and width (10 ns minimum). Program the instrument for EXTERNAL TRIGGER and for positive or negative TRIGGER POLARITY, depending on the polarity of the input signal.
- c. Program the remaining pulse parameters as desired. Parameters may be programmed in any order, however it is a good idea to program V_{UL} and V_{LL} first since they require a longer programming time. Observe the maximum duty cycle limitations listed in paragraph 3.1.1.

Figure 3-1. Parallel Input Sample Program

Parameter	Range BCD Setting	Mode Select	Vernier BCD Setting			
			MSD	MD	LSD	
	1 2 4		1 2 4 8	1 2 4 8	1 2 4 8	
REP RATE	1 0 0		0 1 0 0	0 0 0 0	0 0 0 0	(2.00 MHz)
DELAY	1 0 0		1 0 1 0	0 0 0 0	0 0 0 0	(50.0 ns)
WIDTH	1 0 0		1 0 1 0	0 0 0 0	0 0 0 0	(50.0 ns)
V _{UL}	1 1		1 0 0 1	1 0 0 1	1 0 0 1	(+9.99 V)
V _{LL}	1 1		1 0 1 0	0 0 0 0	0 0 0 0	(+5.00 V)
T ₊ (Model 154)	0 1 0		1 0 0 1	1 0 0 1	1 0 0 1	(9.99 ns)
T ₋ (Model 154)	0 1 0		1 0 0 1	1 0 0 1	1 0 0 1	(9.99 ns)
EXT TRIGGER		0				(disabled)
+TRIG POLARITY		0				(disabled)
SYNC GATE		0				(disabled)
ASYN GATE		0				(disabled)
PULSE PAIRS		0				(disabled)
COMPLEMENT		0				(disabled)
OUTPUT OFF		0				(disabled)

NOTE: A true or a logical one (1) enables the range or vernier bit, or the mode of operation. A false input or a logical zero (0) disables it.

Figure 3-2. Output Waveform Sample Program



Scope Setting: 1 V/cm, 20 ns/cm

CAUTION

The maximum difference between V_{UL} and V_{LL} should not exceed 10 volts and V_{LL} should never be set more positive than V_{UL} .

- d. Connect the OUTPUT connector to the load. Terminate the OUTPUT with 50 ohms if the load does not have 50 ohms impedance.

3.3.1.3 Internal Trigger Mode

With the instrument in the INTERNAL TRIGGER mode (external trigger disabled) the instrument will generate pulses at a rate set by the REP RATE controls. To operate the instrument in the INTERNAL TRIGGER mode proceed as follows:

- a. Connect the programming source to connectors J1 and J2.
- b. Program the instrument for the INTERNAL TRIGGER mode (external trigger mode disabled).
- c. Program the instrument for the desired REPETITION RATE. Program the remaining pulse parameters as desired.
- d. Connect the OUTPUT connector to the load. Terminate the OUTPUT with 50 ohms if the load does not have 50 ohms impedance.

3.3.1.4 Gate Mode

When the SYNC GATE or ASYNC GATE mode is enabled, the output pulse will occur for the duration of a +1 to +5 V pulse applied at the SYNC GATE or ASYNC GATE input. In the SYNC GATE mode the output pulse is synchronized to the gate signal. In the ASYNC GATE mode the output is

not synchronized to the gate signal. To operate the instrument in the SYNC GATE mode proceed as follows:

- a. Program the instrument for the SYNC GATE mode and connect the gate signal source to the SYNC GATE input. Set the pulse amplitude of the gate source for at least +1 volt (but less than +5 volts).
- b. Program the remaining pulse parameters as desired.

NOTE: The repetition rate period should be set to less than the duration (width) of the gate pulse.

- c. Connect the OUTPUT connector to the load. The gated output will be synchronized to the gate signal.
- d. For asynchronous gating, program the instrument for the ASYNC GATE mode and connect the gate signal source to the ASYNC GATE input. Set the pulse amplitude of the gate source for at least +1 volt (but less than +5 volts).
- e. Connect the OUTPUT connector to the load. The gated output will not be synchronized to the gate signal.

3.3.2 Serial Input (Model 153/154-3)

Programming of Model 153/154-3 is accomplished by 12-bit characters entered serially. Ten 12-bit characters are required to completely program Model 153-3 and 14 are required to completely program Model 154-3. Each major parameter (REP RATE, DELAY, WIDTH, V_{UL} , V_{LL} , T_+ and T_-) require two 12-bit characters for complete programming. The first four bits of each character programs the address information, and the first four data bits of the A character program the range of the major char-

acter and at least one mode of operation (SYNC GATE, EXT TRIGGER, etc.). The remaining four data bits of character A programs the most significant vernier digit and the 8 data bits of character B programs the middle and the least significant vernier digits. To change the state of any one bit in a character, it is necessary to reprogram the entire character (address and data information) in order for the new information to be entered into storage.

Although the 12-bit characters may be programmed into the Series 150 in any order—i.e., any parameter can be arbitrarily programmed before or after any other—it is strongly recommended that, wherever possible, upper and lower voltage levels (V_{UL} & V_{LL}) be programmed first in any programming sequence. This is because they require a programming time of 3 ms as compared to the $100\mu s$ maximum required to program all remaining parameters.

Positive-going and negative-going transition times (T_+ & T_-) are each independently settable within the same range. Therefore, when a range is programmed for T_+ it simultaneously programs the range for T_- .

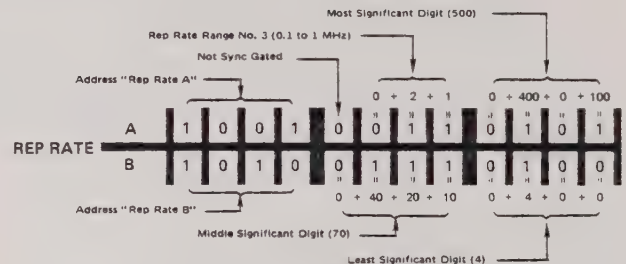
The program information is entered into storage when the trailing edge of the address clock strobe occurs. The delayed clock output occurs approximately 200 ns after the strobe pulse trailing edge. The required clock strobe pulse is positive-going (0 to +5 V) for positive true instruments and negative-going (+5 to 0 V) for ground true instruments. Refer to Figure 2-3 for programming information and connector pin assignments.

3.3.2.1 Sample Program

Figure 3-3 gives two examples of how characters should be programmed. A close study of these two examples will demonstrate how the instrument is operated. Refer to Figure 2-3 for pin assignments. Refer to the range coding chart for range numbers.

EXAMPLE NO. 1

Assume non-gated operation. Set Rep Rate to 574 kHz.



EXAMPLE NO. 2

Set Positive transition Time (T_+) to 169 ns.

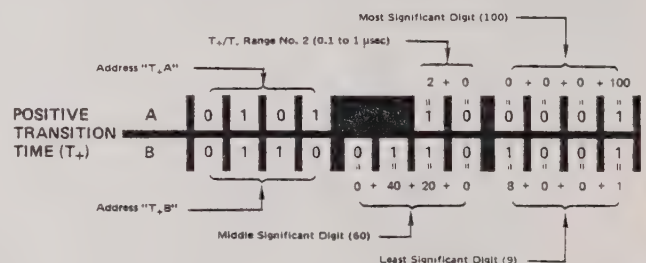


Figure 3-3. Serial Input Sample Program

3.3.2.2 External Trigger Mode

- To operate the instrument in the EXTERNAL TRIGGER mode perform paragraph 3.3.1.2.

3.3.2.3 Internal Trigger Mode

- To operate the instrument in the INTERNAL TRIGGER mode perform paragraph 3.3.1.3.

3.3.2.4 Gate Mode

- To operate the instrument in the SYNC or ASYNC GATE mode perform paragraph 3.3.1.4.

SECTION IV

MAINTENANCE

CAUTION

When re-installing D/A cards check carefully to ensure that card is being installed in appropriate connector; all D/A cards have the same polarising key slots.

4.1 PREVENTIVE MAINTENANCE

Proper care and correct use with regularly scheduled inspections provide the best protection against unnecessary repairs and down time. The Datapulse Series 153/154 Pulse Generators are sensitive laboratory instruments and should not be exposed to severe environmental conditions either in use or in storage. Contaminating or damaging exposure must be avoided at all times if long life and uninterrupted service are expected.

4.1.1 Inspection

Remove the top and bottom covers by removing two flat head Phillips screws on each cover. Inspect for dirt and corrosion and for loose, broken, or burnt parts and wiring. Circuit board discoloration caused by heat may usually be disregarded unless the instrument is inoperative. Inspection intervals should be based on frequency of use and the severity of the environment to which the instrument is exposed.

4.1.2 Cleaning

Accumulated dust and dirt should be removed as often as required. Use either low velocity dry air or a soft nonmetallic brush to clear the interior of foreign matter. Clean dirty parts with a solvent such as trichlorethylene using a soft cloth, and a cotton tipped applicator for narrow spaces.

4.1.3 Recalibration

The instrument is correctly calibrated when it leaves the factory. However, calibration should be checked at regularly scheduled intervals of either accumulated operating hours or calendar time: 500 operating hours or six month intervals is recommended. Refer to paragraph 4.3 for complete calibration instructions.

4.2 PARTS REPLACEMENT

A procedure should be carefully thought out before a part is removed to avoid unnecessary disassembly and accidental damage. Use only direct replacements for parts affecting performance. Transistors temporarily removed should be returned to their original sockets unless defective. Replacement of some parts will necessitate partial recalibration.

4.2.1 Power Transistors

The power transistors for the dc power supplies are mounted on heat sinks. Fiber bushings and mica washers are used to electrically insulate the case (collector) from the heat sink (ground) and a thin film of thermal compound (Wakefield No. 122) is applied to both sides of the mica washers to insure proper thermal conductivity. Incorrectly installed, the transistors may either short out or overheat and fail.

4.2.2 Soldering

Only experienced technicians should replace soldered parts. Printed circuits are vulnerable to excess heat as are many diodes and transistors. The following recommendations should be taken into consideration when replacing soldered parts:

- a. Use small diameter rosin core solder and a 35 to 40 watt iron with a wedge

- or pointed tip, 1/16 to 1/8 inch wide. The tip must be clean and properly tinned with excess solder removed.
- b. Obviously defective parts may be clipped out so their leads can be conveniently unsoldered from the board.
- c. Solder only on the circuit side of the board; not on the component side.
- d. Apply the tip of the iron directly to the solder joint, at the eyelet, just long enough for the solder to flow.
- e. Avoid bringing the iron into contact with the circuit board; overheating will cause the conductor to lift from the board.
- f. Use a solder sipper (or some other means) to remove excess solder first when unsoldering a lead, particularly where a lead is bent over, so that it can be straightened before it is pulled out.
- g. When a lead is free, clean the hole and remove excess solder, using a solder sipper or a sharp object such as a tooth pick or pointed tool.
- h. To prevent heat damage when soldering heat sensitive components, use a heat sink or long nose pliers to grip the lead between the part and the board.
- i. Clean the area thoroughly after soldering.

4.3 CALIBRATION

Paragraph 4.3.2 through 4.3.8 provide a complete calibration procedure for the Series 153/154 instruments. Since some adjustments interact with others, follow the procedure in the step sequence given. Refer to Figure 4-1 through 4-3 for the location of calibration adjustments and test points.

4.3.1 Equipment (or equivalent) Required

- a. Digital voltmeter with an accuracy of 0.1%. Systron-Donner Model 7050 recommended.
- b. Real-time oscilloscope with a dc to 50 MHz bandwidth. Tektronix Type 546 with a Type 1A2 plug-in recommended.
- c. Sampling oscilloscope with a 0.35 ns rise time. Tektronix Type 546 with a Type 1S1 plug-in recommended.
- d. A 50 ohm, 5 watt coaxial termination, Datapulse Type 2011 recommended.
- e. A 50 ohm, 2 watt coaxial termination. Datapulse Type 2010 recommended.
- f. Variable autotransformer with a 2 amp capacity.
- g. Electronic counter with a 50 MHz repetition rate capability. Systron-Donner Model 7015 recommended.
- h. Two 50 ohm, 2 watt coaxial 10X attenuators. Datapulse Type 2015 recommended.
- i. Several 50 ohm coaxial cables terminated with BNC connectors.

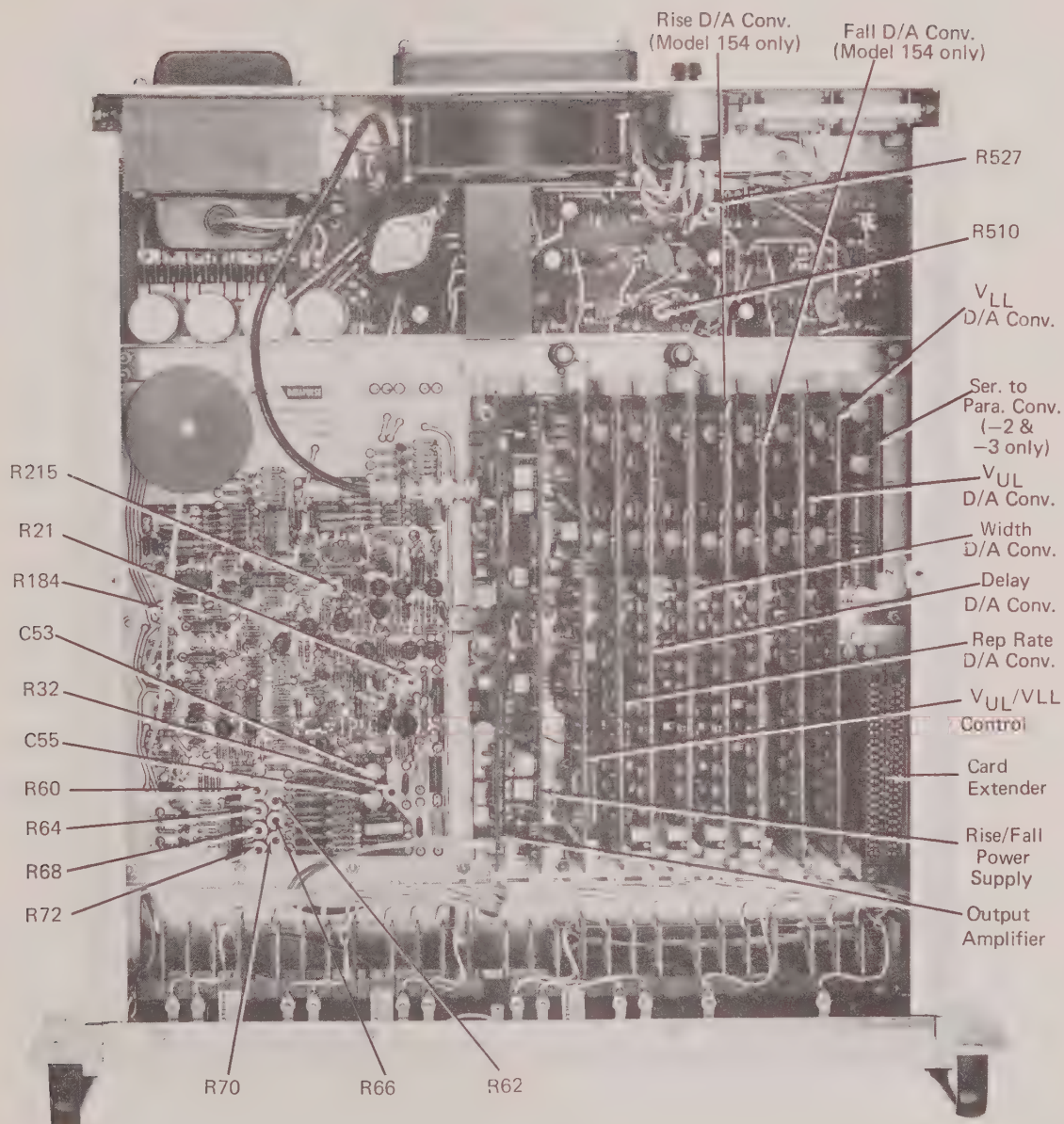


Figure 4-1. Model 153/154 – Top View

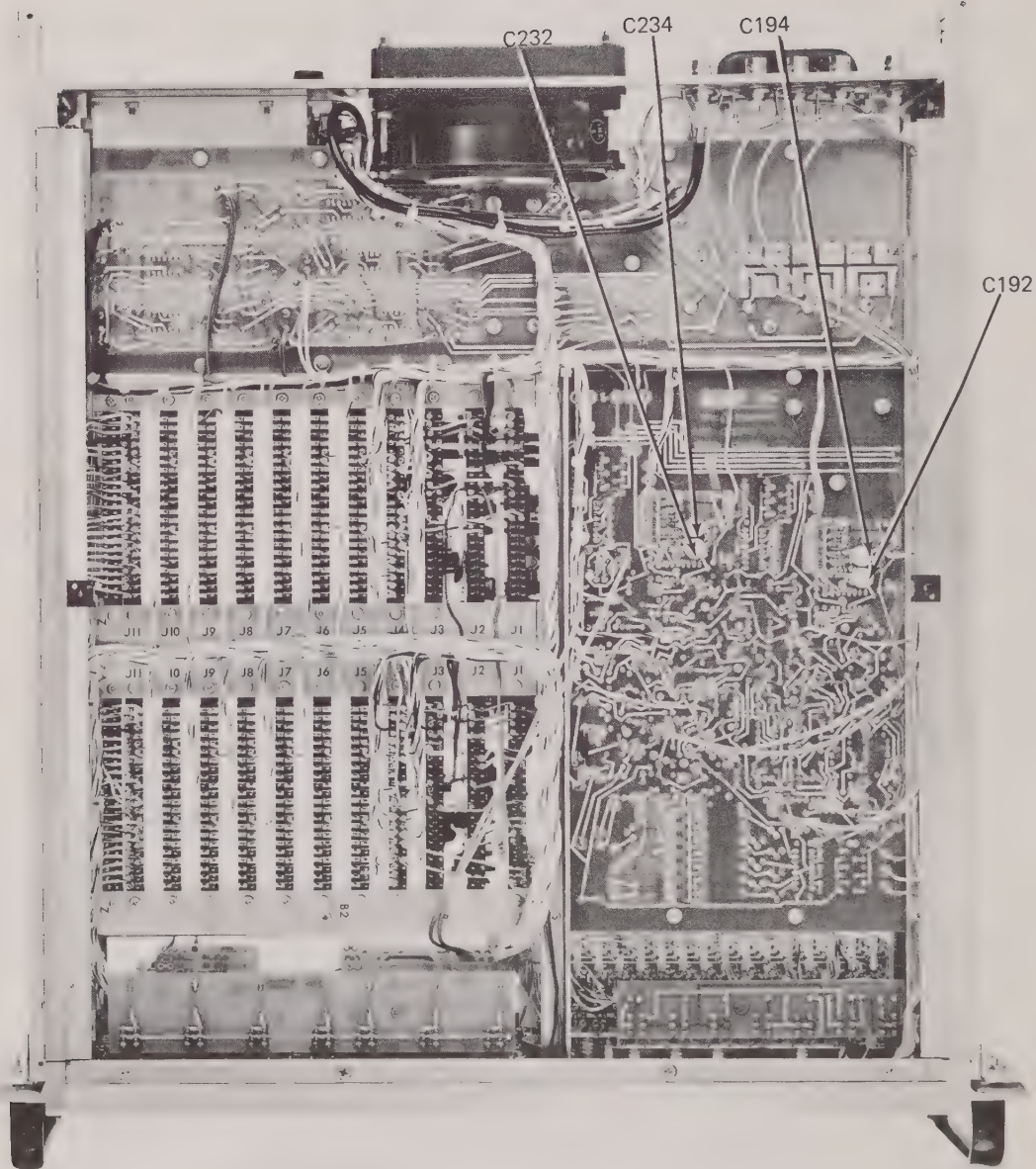


Figure 4-2. Model 153/154 — Bottom View

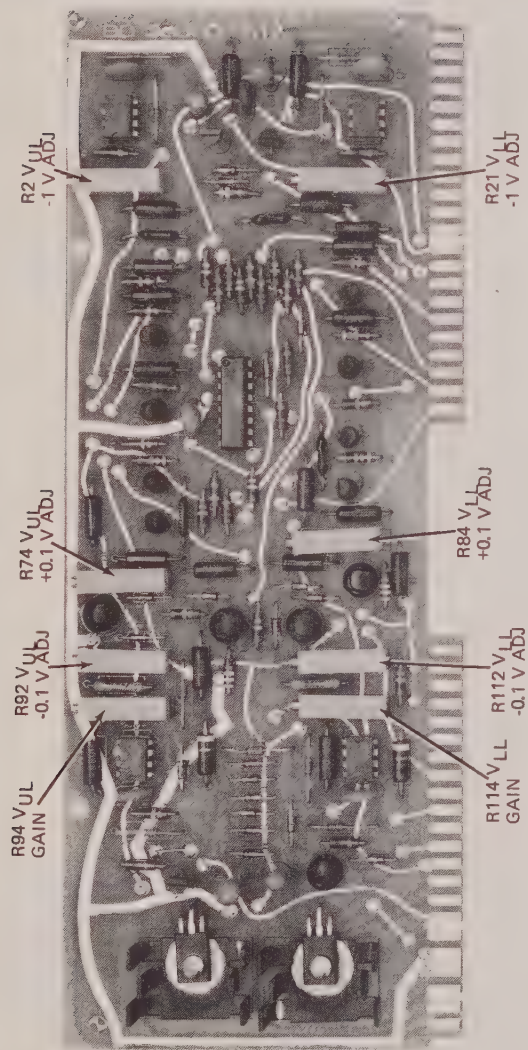


Figure 4-3a. V_{UL}/V_{LL} Control Circuit Adjustments

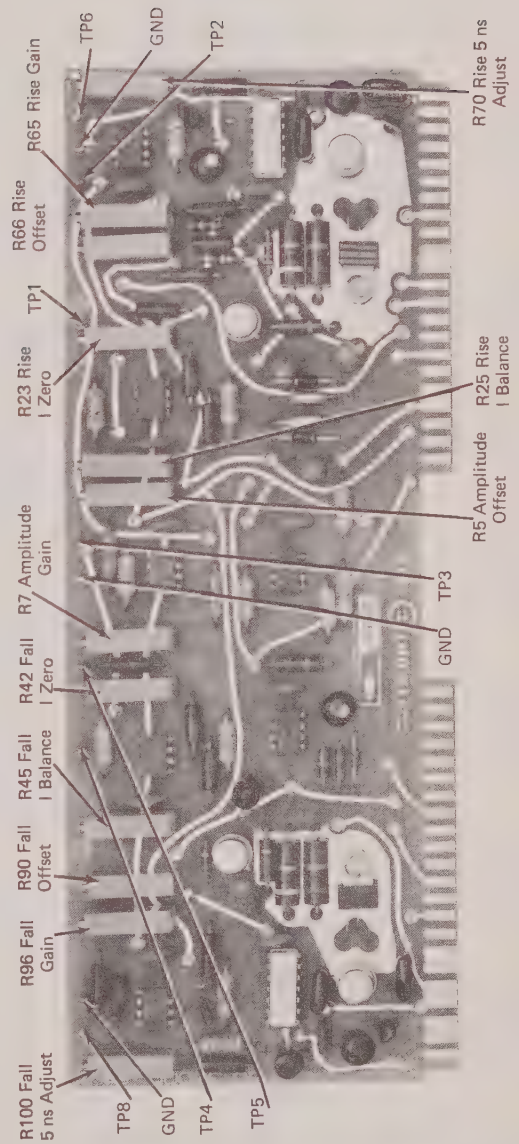


Figure 4-3b. Rise/Fall Power Supply Adjustments

4.3.2 Power Supply Calibration**CAUTION**

Verify that the position of the slide switch on the back panel agrees with the line voltage prior to connecting the power plug.

- a. Connect the instrument to the auto-transformer. Set the autotransformer for 115 volts. Actuate the POWER switch to "on".
- b. Connect the digital voltmeter between the +25 volt test point (5B) and ground (5K). Adjust R510 for +25.00 volts dc.
- c. Connect the voltmeter between the -25 volt test point (5D) and ground (5K). Adjust R527 for -25.00 volts dc.
- d. Connect the voltmeter between the +5 volt test point (5F) and ground (5K). Verify a reading of $+5 \pm 0.1$ volts dc.
- e. Connect the voltmeter between the -5 volt test point (5J) and ground (5K). Verify a reading of -5 ± 0.04 volts dc.
- f. Connect the voltmeter between the +2 volt test point (5G) and ground (5K). Verify a reading of $+2 \pm 0.04$ volts dc.

4.3.3 Hyperbolic D/A Converters

Refer to Figure 4 - 1 for the location of the D/A converters. Set all parameter thumbwheels to 000. Install serial to parallel converter card.

4.3.3.1 Delay D/A Converter

- a. Set the DELAY thumbwheels to 999 on any range. Adjust R65 fully clockwise. Connect the digital voltmeter across R71 on the delay D/A converter. Adjust R72 for +1.365 V.
- b. Retain digital voltmeter setting across R71. Set the DELAY thumbwheels for the following settings and verify the readings on the digital voltmeter are approximately those given.

<u>Setting</u>	<u>Voltmeter Reading</u>
888	1.537 V
777	1.746 V
666	2.035 V
555	2.433 V
444	3.037 V
333	4.038 V
222	5.986 V
111	11.797 V
000	13.60 V

- c. Set thumbwheels to 100; increment second digit from one to nine and observe that reading decreases with each step.
- d. Repeat procedure in step (c) for least significant (third) digit.
- e. After subsequent parts of this procedure are performed, these readings will change. Therefore, a working, calibrated instrument may have different readings from those shown here. If R65 or R72 are adjusted (changed), the entire Delay Calibration procedure must be redone.

4.3.3.2 Width D/A Converter

- a. Set the WIDTH thumbwheels to 999 on any range. Adjust R65 fully clockwise. Connect the digital voltmeter across R71. Adjust R72 for $1.365 \text{ V} \pm 5 \text{ mV}$.
- b. Perform steps (b) through (d) provided in paragraph 4.3.3.1 following adjustment of R72. Repeat step (e), substituting "Width Calibration" for "Delay Calibration".

4.3.4 Repetition Rate Calibration

- a. Connect the TRIG OUT connector to the input of the counter. Terminate with the 50 ohm, 5 watt termination at the input to the counter.
- b. Set the REP RATE thumbwheels to 100 kHz on the 0.1 to 1 MHz range. Set the remaining parameter thumbwheels to 000. Release all push-buttons except MAN CONT push-button.
- c. Adjust R21 for a reading of 100 kHz $\pm 5 \text{ kHz}$.
- d. Set the REP RATE thumbwheels for 999 kHz. Adjust R64 for a reading of 1.00 MHz $\pm 50 \text{ kHz}$.
- e. Set the REP RATE thumbwheels for 800 kHz. Adjust R32 for 800 kHz $\pm 40 \text{ kHz}$.
- f. Starting at 100 kHz, check the entire range at 100 kHz intervals, verifying that all of the readings are within $\pm 5\%$ of the thumbwheel settings. If any readings are out of tolerance, readjust R21, R32 and R64 as required to get all of the readings in tolerance.

- g. Set the REP RATE thumbwheels for 1.00 MHz on the 1–10 MHz range. Adjust C55 for 1.00 MHz $\pm 50 \text{ kHz}$.
- h. Set the REP RATE thumbwheels for 9.99 MHz. Adjust R62 for 10.0 MHz $\pm 500 \text{ kHz}$.
- i. Starting at 1.00 MHz, check the entire range at 1.00 MHz intervals verifying that all of the readings are within $\pm 5\%$ of the thumbwheel settings.
- j. Set the REP RATE thumbwheels for 10.0 MHz in the 10–50 MHz range. Adjust C53 for a reading of 10.0 MHz $\pm 500 \text{ kHz}$.
- k. Set the REP RATE thumbwheels for 50.0 MHz. Adjust R60 for a reading of 50.0 MHz $\pm 2.5 \text{ MHz}$.
- l. Starting at 10.0 MHz, check the entire range at 10.0 MHz intervals verifying that all of the readings are within $\pm 5\%$ of the thumbwheel settings.
- m. Set the REP RATE thumbwheels for 99.9 kHz on the 10–100 kHz range. Adjust R66 for a reading of 100 kHz $\pm 5 \text{ kHz}$.
- n. Starting at 10.0 kHz, check the entire range at 10.0 kHz intervals verifying that all of the readings are within $\pm 5\%$ of the thumbwheel settings.
- o. Set the REP RATE thumbwheels for 9.99 kHz on the 1–10 kHz range. Adjust R68 for a reading of 10.0 kHz $\pm 500 \text{ Hz}$.
- p. Starting at 1.00 kHz, check the entire range at 1.00 kHz intervals verifying that all of the readings are within $\pm 5\%$ of the thumbwheel settings.

- q. Set the REP RATE thumbwheels for 999 Hz on the 100–1000 Hz range. Adjust R70 for a reading of 1000 Hz ± 50 Hz.
- r. Starting at 100 Hz, check the entire range at 100 Hz intervals verifying that all of the readings are within $\pm 5\%$ of the thumbwheel settings.
- s. Set the REP RATE thumbwheels for 99.9 Hz on the 10–100 Hz range. Adjust R72 for a reading of 100 Hz (10 ms period) ± 5 Hz.
- t. Starting at 10.0 Hz, check the entire range at 10.0 Hz intervals verifying that all of the readings are within $\pm 5\%$ of the thumbwheel settings.

4.3.5 Delay Range Calibration

- a. Connect the OUTPUT connector to the input of the real-time oscilloscope. Terminate with the 50 ohm, 5 watt termination at the oscilloscope. Trigger the oscilloscope from the TRIG OUT connector. Terminate with the 50 ohm, 1 watt termination at the oscilloscope.
- b. Set the instrument controls as follows:

<u>Control</u>	<u>Setting</u>
REP RATE	50 kHz (10–100 kHz range)
DELAY	9.99 μ s (1–10 μ s range)
WIDTH	100 ns (0.1–1 μ s range)
RISE (Model 154-1 only)	5 ns (5–10 ns range)
FALL (Model 154-1 only)	5 ns (5–10 ns range)

<u>Control</u>	<u>Setting</u>
V _{UL}	+9.99 V (+10 V range)
V _{LL}	+1.00 V (+1 V range)
MAN CONT	depressed
DBL PULSE	depressed
Remaining pushbuttons	released

- c. Adjust R184 for a delay of 10.0 μ s $\pm 0.5 \mu$ s (measured from the 50% point on the leading edge of the first pulse to the 50% point on the leading edge of the second pulse). Set the DELAY thumbwheels for 1.00 μ s. Adjust R65 on the Delay D/A Converter for 1.00 μ s.
- d. Starting at 1.00 μ s, check the entire range at 1.00 μ s intervals verifying that all of the readings are within $\pm 5\%$ of the thumbwheel settings.
- e. Check the 10–100 μ s, 100–1000 μ s and 1–10 ms ranges at 10% intervals verifying that all readings are within $\pm 5\%$ of the thumbwheel settings. Change repetition rate as required to prevent exceeding the duty factor limitations. If any readings are out of tolerance, readjust R184 and R65 on the Delay D/A Converter to get all four ranges in tolerance.
- f. Disconnect the OUTPUT connector from the real-time oscilloscope. Terminate the output with the 50 ohm, 2 watt, 10X attenuator and connect it to the input of the sampling oscilloscope. Trigger the oscilloscope from the TRIG OUT connector.
- g. Set the REP RATE thumbwheels for 500 kHz and WIDTH thumbwheels for 100 ns.

- h. Set the DELAY thumbwheels to 999 ns on the 100–1000 ns range. Adjust C194 for a delay of 1000 ns ± 50 ns. Reduce the pulse width to 10 ns.
- i. Starting with 100 ns, check the entire range at 100 ns intervals verifying that all of the readings are within $\pm 5\%$ of the thumbwheel settings.
- j. Set the REP RATE thumbwheels for 5 MHz and the WIDTH thumbwheels for 10 ns.
- k. Set the DELAY thumbwheels for 99.9 ns on the 10–100 ns range. Adjust C192 for a delay of 100 ns ± 5 ns.

NOTE: To measure delays less than 20 ns, switch to single pulse mode and measure delay from the leading edge of the TRIG OUT pulse.

- l. Starting at 10 ns, check the entire range at 10.0 ns intervals verifying that all of the readings are within $\pm 5\% +1$ ns of the thumbwheel settings.

4.3.6 Width Range Calibration

- a. Perform the test set-up the same as in paragraph 4.3.5 step (a).
- b. Set the instrument controls the same as in paragraph 4.3.5 step (b), except set the DELAY thumbwheels to 10.0 ns on the 10–1000 ns range, the WIDTH thumbwheels to 9.99 μ s on the 1–10 μ s range and the DBL PULSE pushbutton to the released position.
- c. Adjust R215 for a pulse width of 10.0 μ s ± 0.5 μ s (measured from the 50% point on the leading edge to the 50% point on the trailing edge). Set the WIDTH thumbwheels for 1.00 μ s. Adjust R65 on the width D/A converter for 1.00 μ s.
- d. Starting at 1.00 μ s, check the entire range at 1.00 μ s intervals verifying that all of the readings are within $\pm 5\%$ of the thumbwheel settings.
- e. Check the 10–100 μ s, 100–1000 μ s and 1–10 ms ranges at 10% intervals verifying that all readings are within $\pm 5\%$ of the thumbwheel settings. Change repetition rate as required to prevent exceeding the duty cycle limitations. If any readings are out of tolerance readjust R215 and R65 to get all four ranges in tolerance.
- f. Disconnect the OUTPUT connector from the real-time oscilloscope. Terminate the output with a 50 ohm, 2 watt, 10X attenuator and connect it to the input of the sampling oscilloscope. Trigger the oscilloscope from the TRIG OUT connector.
- g. Set the REP RATE thumbwheels to 500 kHz. Set the WIDTH thumbwheels for 999 ns on the 100–1000 ns range. Adjust C234 for a pulse width of 1000 ns ± 50 ns.
- h. Starting at 100 ns, check the entire range at 100 ns intervals verifying that all of the readings are within $\pm 5\%$ of the thumbwheel settings.
- i. Set the REP RATE thumbwheels to 5 MHz. Set the WIDTH thumbwheels to 99.9 ns on the 10–100 ns range. Adjust C232 for a pulse width of 100 ns ± 5 ns.

- j. Starting at 10.0 ns, check the entire range at 10.0 ns intervals verifying that all of the readings are within $\pm 5\%$ ± 1 ns of the thumbwheel settings.

4.3.7 Rise/Fall Power Supply Calibration (Model 154—1 and 3)

All calibration potentiometers and test points referred to in this paragraph are located on the rise and fall power supply card unless otherwise specified. (Refer to Figure 4-3b).

- a. Connect instrument to sampling oscilloscope; terminate with 50 ohm, 2 W coaxial attenuator at oscilloscope.
- b. Set the instrument controls as follows:

<u>Control</u>	<u>Setting</u>
REP RATE	100 kHz (100—1000 kHz range)
DELAY	10 ns (10—100 ns range)
WIDTH	3 μ s (1—10 μ s range)
RISE	1 μ s (1—10 μ s range)
FALL	1 μ s (1—10 μ s range)
V _{UL}	+9.99 V (+10 V range)
V _{LL}	0.00 V (-10 V range)
MAN CONT	depressed
Remaining pushbuttons	released

- c. Set oscilloscope controls to display single pulse on trace.
- d. Monitor TP3 with digital voltmeter and adjust AMPLITUDE GAIN to 10.000 volts.

- e. Connect digital voltmeter between TP1 and TP2 and ground TP3. Adjust RISE I ZERO for 0.000 volts.
- f. Remove ground from TP3 and adjust RISE I BALANCE for minimum change on digital voltmeter reading when rise time is shifted from 1 μ s to 9 μ s.
- g. Set oscilloscope controls to enable display of pulse leading edge, and adjust RISE GAIN for a rise time of 1 μ s at +9.99 volts amplitude.
- h. Set V_{UL} for +1.99 V amplitude and adjust AMPLITUDE OFFSET for a rise time of 1 μ s.
- i. Set V_{UL} for +9.99 volts amplitude and monitor TP3 with digital voltmeter; readjust AMPLITUDE GAIN for 10.000 volts.
- j. Repeat steps (h) and (i) until both readings remain correct.
- k. Set instrument controls as follows:

<u>Control</u>	<u>Setting</u>
REP RATE	10 kHz (10—100 kHz range)
DELAY	10 ns (10—100 ns range)
WIDTH	30 μ s (10—100 μ s range)
RISE	9 μ s (1—10 μ s range)
FALL	9 μ s (1—10 μ s range)
V _{UL}	+1.99 V (+10 V range)
V _{LL}	0.00 V (-10 V range)
RISE OFFSET	Adjust for rise time of 9 μ s

- l. Set instrument controls as indicated in step (b) and oscilloscope controls as indicated in step (c).

- m. Connect digital voltmeter between TP5 and TP4 and ground TP3. Adjust FALL I ZERO for reading of 0.000 volts.

- n. Remove ground from TP3 and adjust FALL I BALANCE for minimum change on digital voltmeter when fall time is shifted from $1\mu\text{s}$ to $9\mu\text{s}$.

- o. Set oscilloscope controls to display trailing edge of pulse; adjust FALL GAIN for fall time of $1\mu\text{s}$ at +9.99 volts amplitude.

- p. Set instrument controls as indicated in step (k) and adjust oscilloscope controls as required to observe trailing edge of pulse. Adjust FALL OFFSET for a fall time of $9\mu\text{s}$.

- q. Set instrument controls as follows:

<u>Control</u>	<u>Setting</u>
REP RATE	1 MHz (1-10 MHz range)
DELAY	10 ns (10-100 ns range)
WIDTH	30 ns (10-100 ns range)
RISE	5 ns (5-10 ns range)
FALL	5 ns (5-10 ns range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	0.00 V (-10 V range)

- r. Set oscilloscope controls to display single pulse on trace.

- s. Set RISE 5 NS ADJUST for reading of 5 ns rise time. Set FALL 5 NS ADJUST for reading of 5 ns fall time.

4.3.8 V_{UL} and V_{LL} Calibration

All calibration potentiometers and test points referred to in this paragraph are located on the V_{UL}/V_{LL} control card unless otherwise specified. (Refer to Figure 4-3a).

- a. Connect the OUTPUT connector to the input of the digital voltmeter. Terminate the output with the 50 ohm, 5 watt termination at the digital voltmeter input.

- b. Set instrument controls as follows:

<u>Control</u>	<u>Setting</u>
REP RATE	10.0 Hz (10-100 Hz range)
DELAY	10.0 ns (10-100 ns range)
WIDTH	10.0 ns (10-100 ns range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	0.00 V (-10 V range)
MAN CONT	depressed
OUTPUT COMPLETE	depressed
Remaining pushbuttons	released

- c. Adjust R94 for an initial setting of +10.00 V dc. In subsequent steps it may be necessary to readjust the value.

- d. Set V_{UL} to -0.1 V and V_{LL} to -5.00 V. Adjust R92 for -0.1 V. If R92 cannot be set properly, proceed to step (e).

- e. Set V_{UL} to -1.0 V (-10.00 V range), adjust R2 for -1.0 V. Repeat step (d) and verify that voltage adjustment of -1.0 V remains constant.

- f. Set V_{UL} for +10.00 V and V_{LL} for 0.00 V. Check entire V_{UL} range at 1 volt intervals and verify that voltage readings are within 5% of thumbwheel settings. If any reading is out of tolerance, readjust R94 (upper end) and R2 (lower end) as necessary.
- g. Set V_{UL} for -9.00 V and V_{LL} for -10.00 V. Check entire V_{UL} range at 1 volt intervals and verify that voltage readings are within 5% of thumbwheel settings.

NOTE: Any adjustment of R94 effects the entire V_{UL} range. Therefore, if correct indication cannot be obtained in step (g), repeat adjustment indicated in step (f).

- h. Set V_{UL} to +0.1 V (+1.00 V range) and V_{LL} to -5.00 V (-10.00 V range). Adjust R74 for +0.1 V.
- i. Verify that +1.0 V and -1.0 V V_{UL} ranges are within 5% (or 50 mV) of the thumbwheel settings over entire range at 100 mV intervals.
- j. Release the OUTPUT COMPLETE pushbutton.
- k. Set the V_{LL} thumbwheels to +9.00 V and V_{UL} to +10.00 V. Adjust R114 for +9.99 V dc.
- l. Set V_{LL} to -0.1 V and V_{UL} to +5.00 V. Adjust R112 for -0.1 V.
- m. Set V_{LL} to -1.00 V (-10.00 V range). Adjust R21 for -1.00 V. Repeat step (l); verify that voltage adjustment of -1.00 V remains constant.

- n. Set V_{LL} for +9.00 V and V_{UL} to +10.00 V. Check entire V_{LL} range at 1 volt intervals and verify that the voltage readings are within 5% of thumbwheel settings. If any reading is out of tolerance, readjust R114 (upper end) and R21 (lower end).
- o. Set V_{UL} to 0.00 V and V_{LL} to -10.00 V. Check entire V_{LL} range at 1 volt intervals and verify that voltage readings are within 5% of thumbwheel settings.

NOTE: Any adjustment of R114 effects the entire V_{LL} range. Therefore, if correct indications cannot be obtained in step (o), repeat adjustment indicated in step (n).

- p. Set V_{LL} to +0.1 V and V_{UL} to +5.00 V. Adjust R84 for +0.1 V.
- q. Verify that +1 V and -1 V V_{LL} ranges are within 5% (or 50 mV) of the thumbwheel settings over entire range at 100 mV intervals.
- r. Verify that all rise/fall readings are within tolerance $\pm(5\% + 1 \text{ ns})$ of thumbwheel settings, 10% at less than 2 volts amplitude. If any reading is out of tolerance, repeat steps (g) through (k) for rise time and steps (m) through (q) for fall time of previous paragraph 4.3.7.

NOTE: If the 1–10 μs range cannot be adjusted to specifications or the 10–100 ns or 0.1–1 μs range is out of tolerance, the value of the timing capacitor in the output amplifier (37000 - 954) can be varied slightly. Capacitor C4 is for the 10–100 ns range, C7 is for the 0.1–1 μs range and C10 is for the 1–10 μs range. The 5–10 ns range has no timing capacitor.

4.4 SPECIFICATION VERIFICATION

This section is designed to assist in comparing the Model 153/154 with the published specifications. These checks may be used for incoming inspection and after repair checks. If the instrument does not meet the requirement outlined in this section, refer to the calibration procedure (paragraph 4.3).

4.4.1 Equipment (or equivalent) Required

The same equipment listed in paragraph 4.3.1 can be used in these checks.

4.4.2 Repetition Rate Check

- Monitor the OUTPUT connector with the counter. Terminate the OUTPUT with the 50 ohm, 5 watt termination.
- Set the instrument controls as follows:

<u>Control</u>	<u>Setting</u>
REP RATE	10 Hz (10-100 Hz range)
WIDTH	10 ns (10-100 ns range)
DELAY	10 ns (10-100 ns range)
RISE/FALL (Model 154 only)	5 ns (5-10 ns range)
V _{UL}	+9.99 V (+10 V range)
V _{LL}	0.00 V (+1 V range)
MAN CONT	depressed
Remaining pushbuttons	released

- Perform Table 4 - 1 for the repetition rate ranges. Verify that all readings are within $\pm 5\%$ of the thumbwheel settings.

4.4.3 Delay Check

- Monitor the OUTPUT with the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination at the oscilloscope input. Trigger the oscilloscope from the TRIG OUT connector.
- Set the instrument controls the same as in paragraph 4.4.2 step (b) except set the DELAY for 1.00 ms on the 1-10 ms range and depress the DBL PULSE pushbutton.
- Perform Table 4 - 2 for the delay ranges. Verify that all readings are within $\pm 5\%$ of the thumbwheel settings. Change the repetition rate as required to remain within the duty cycle limitations. Delays less than 20 ns must be measured from the TRIG OUT pulse. Use the sampling oscilloscope to check the 0.1-1 μ s and the 10-100 ns ranges. Attenuate the output as required when using the sampling oscilloscope.

4.4.4 Width Checks

- Monitor the OUTPUT with the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination at the oscilloscope input. Trigger the oscilloscope from the TRIG OUT connector.
- Set the instrument controls the same as in paragraph 4.4.2 step (b) except set the WIDTH for 1.00 ms on the 1-10 ms range. Set the oscilloscope controls to display a single pulse on the trace.
- Perform Table 4 - 2 for the width ranges. Verify that all readings are

Table 4-1. Repetition Rate Checks

Thumbwheel Setting	Counter Indication					
	10-100 Hz Range	100-1000 Hz Range	1-10 kHz Range	10-100 kHz Range	0.1-1 MHz Range	1-10 MHz Range
100	95 to 105 ms	95 to 105 Hz	950 to 1050 Hz	9.5 to 10.5 kHz	95.0 to 105 kHz	0.95 to 1.05 MHz
200	47.5 to 52.5 ms	190 to 210 Hz	1.9 to 2.1 kHz	19.0 to 21.0 kHz	190 to 210 kHz	1.9 to 2.1 MHz
300	31.3 to 34.7 ms	285 to 315 Hz	2.85 to 3.15 kHz	28.5 to 31.5 kHz	285 to 315 kHz	2.85 to 3.15 MHz
400	23.7 to 26.3 ms	380 to 420 Hz	3.8 to 4.2 kHz	38.0 to 42.0 kHz	380 to 420 kHz	3.8 to 4.2 MHz
500	19 to 21 ms	475 to 525 Hz	4.75 to 5.25 kHz	47.5 to 52.5 kHz	475 to 525 kHz	4.75 to 5.25 MHz
600	15.8 to 17.4 ms	570 to 630 Hz	5.7 to 6.3 kHz	57.0 to 63.0 kHz	570 to 630 kHz	5.7 to 6.3 MHz
700	13.5 to 14.9 ms	665 to 735 Hz	6.65 to 7.35 kHz	66.5 to 73.5 kHz	665 to 735 kHz	6.65 to 7.35 MHz
800	11.9 to 13.1 ms	760 to 840 Hz	7.6 to 8.4 kHz	76.0 to 84.0 kHz	760 to 840 kHz	7.6 to 8.4 MHz
900	10.6 to 11.7 ms	855 to 945 Hz	8.55 to 9.45 kHz	85.5 to 94.5 kHz	855 to 945 kHz	8.55 to 9.45 MHz
999	09.5 to 10.5 ms	950 to 1050 Hz	9.5 to 10.5 kHz	95.0 to 105 kHz	95.0 to 105 kHz	9.5 to 10.5 MHz

Table 4-2. Delay/Width Checks

Thumbwheel Setting	Oscilloscope Indication*					
	1-10 ms Range	0.1-1 ms Range	10-100 μ s Range	1-10 μ s Range	0.1-1 μ s Range	10-100 ns Range
100	0.95 to 1.05 ms	95.0 to 105 μ s	9.5 to 10.5 μ s	0.95 to 1.05 μ s	95.0 to 105 ns	9.5 to 10.5 ns
200	1.9 to 2.1 ms	190 to 210 μ s	19.0 to 21.0 μ s	1.9 to 2.1 μ s	190 to 210 ns	19.0 to 21.0 ns
300	2.85 to 3.15 ms	285 to 315 μ s	28.5 to 31.5 μ s	2.85 to 3.15 μ s	285 to 315 ns	28.5 to 31.5 ns
400	3.8 to 4.2 ms	380 to 420 μ s	38.0 to 42.0 μ s	3.8 to 4.2 μ s	380 to 420 ns	38.0 to 42.0 ns
500	4.75 to 5.25 ms	475 to 525 μ s	47.5 to 52.5 μ s	4.75 to 5.25 μ s	475 to 525 ns	47.5 to 52.5 ns
600	5.7 to 6.3 ms	570 to 630 μ s	57.0 to 63.0 μ s	5.7 to 6.3 μ s	570 to 630 ns	57.0 to 63.0 ns
700	6.65 to 7.35 ms	665 to 735 μ s	66.5 to 73.5 μ s	6.65 to 7.35 μ s	665 to 735 ns	66.5 to 73.5 ns
800	7.6 to 8.4 ms	760 to 840 μ s	76.0 to 84.0 μ s	7.6 to 8.4 μ s	760 to 840 ns	76.0 to 84.0 ns
900	8.55 to 9.45 ms	855 to 945 μ s	85.5 to 94.5 μ s	8.55 to 9.45 μ s	855 to 945 ns	85.5 to 94.5 ns
999	9.5 to 10.5 ms	950 to 105 μ s	95.0 to 105 μ s	9.5 to 10.5 μ s	95.0 to 105 ns	9.5 to 10.5 ns

* ALL READINGS ± 1 NS

within $\pm 5\%$ of the BCD (thumb-wheel) settings. Change the repetition rate as required to remain within the duty cycle limitations. Use the sampling oscilloscope to check the $0.1\text{--}1\mu\text{s}$ and the $10\text{--}100\text{ ns}$ ranges. Attenuate the output as required when using the sampling oscilloscope.

4.4.5 V_{UL}/V_{LL} Checks

- Monitor the OUTPUT with the digital voltmeter. Terminate the OUTPUT with the 50 ohm, 5 watt termination.
- Set the instrument controls the same as in paragraph 4.4.2 step (b) except depress the COMPLEMENT push-button and the external trigger pushbutton.
- Perform Table 4 - 3 for the +10 V V_{UL} range then set V_{LL} for -10 V and perform Table 4 - 3 for -10 V V_{LL} range.
- Release the COMPLEMENT push-button and set both V_{UL} and V_{LL} for +10 V. Perform Table 4 - 3 for the +10 V V_{LL} range then set V_{UL} for 0 V and perform Table 4 - 3 for the -10 V V_{LL} range.

CAUTION

When performing Table 4 - 3 the maximum difference between V_{UL} and V_{LL} should not exceed 10 volts and V_{LL} should never be set more positive than V_{UL} . For example, when checking the +10 volt V_{UL} range set V_{LL} at 0 volts and when checking the -10 volt V_{UL} range, set V_{LL} at -10 volts.

4.4.6 Transition Time Checks

4.4.6.1 Fixed Transition Times (Model 153 only)

- Monitor the OUTPUT with the sampling oscilloscope (attenuate as required). Trigger the oscilloscope from the TRIG OUT connector.
- Set the instrument controls the same as in paragraph 4.4.2 step (b), except set the REPETITION RATE for 10 MHz and the WIDTH to 50 ns. Set the oscilloscope controls to display a single pulse on the trace.
- Verify that the rise (T_+) and fall (T_-) times are $< 5\text{ ns}$.

4.4.6.2 Variable Transition Times (Model 154 only)

- Monitor the OUTPUT with the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination at the oscilloscope input.
- Set the instrument controls as follows:

<u>Control</u>	<u>Setting</u>
REP RATE	100 Hz (100-1000 Hz range)
WIDTH	5.00 ms (1-10 ms range)
DELAY	10.0 ns (10-100 ns range)
RISE/FALL	1.00 μs (10-100 μs range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	0.00 V (+1 V range)
MAN CONT	depressed
Remaining pushbuttons	released

Table 4-3. V_{UL}/V_{LL} Range Checks

Thumbwheel Setting	Voltmeter Indication			
	+10 Volt V_{UL} Range	-10 Volt V_{UL} Range	+10 Volt V_{LL} Range	-10 Volt V_{LL} Range
100	0.95 to 1.05 V	-0.95 to -1.05 V	0.95 to 1.05 V	-0.95 to -1.05 V
200	1.9 to 2.1 V	-1.9 to -2.1 V	1.9 to 2.1 V	-1.9 to -2.1 V
300	2.85 to 3.15 V	-2.85 to -3.15 V	2.85 to 3.15 V	-2.85 to -3.5 V
400	3.8 to 4.2 V	-3.8 to -4.2 V	3.8 to 4.2 V	-3.8 to -4.2 V
500	4.75 to 5.25 V	-4.75 to -5.25 V	4.75 to 5.25 V	-4.75 to -5.25 V
600	5.7 to 6.3 V	-5.7 to -6.3 V	5.7 to 6.3 V	-5.7 to -6.3 V
700	6.65 to 7.35 V	-6.65 to -7.35 V	6.65 to 7.35 V	-6.65 to -7.35 V
800	7.6 to 8.5 V	-7.6 to -8.5 V	7.6 to 8.5 V	-7.6 to -8.5 V
900	8.55 to 9.45 V	-8.55 to -9.45 V	8.55 to 9.45 V	-8.55 to -9.45 V
999	9.5 to 10.5 V	-9.5 to -10.5 V	9.5 to 10.5 V	-9.5 to -10.5 V

- c. Perform Table 4-4 for the rise (T_+) and fall (T_-) times. Change the repetition rate and width as required to make the readings. Use the sampling oscilloscope to check the 10–100 ns and 5–10 ns ranges. Attenuate the output as required when using the sampling oscilloscope.

- d. Compute the rise and fall time linearity by the following equation:

$$\%L = \frac{x}{t} 0.100$$

where x = deviation in time from the reference line

and t = time between the 10% and 90% points (see Figure 4-4).

NOTE: The reference line is selected so that maximum + and – deviations are minimized.

- e. Verify that the linearity is $\pm 5\%$ for rise and fall times above 10 ns and 10% for rise and fall times below 10 ns.

4.4.7 Waveform Aberrations Check

- a. Monitor the OUTPUT with the sampling oscilloscope (attenuate as required). Trigger the oscilloscope from the TRIG OUT connector.
- b. Set the instrument controls as follows:

Control	Setting
REP RATE	10 MHz (10–50 MHz range)
WIDTH	50 ns (10–100 ns range)
DELAY	10 ns (10–100 ns range)
RISE/FALL (Model 154 only)	5 ns (5–10 ns range)
V_{UL} controls	9.99 V (+10 V range)
V_{LL} controls	0.00 V (+1 V range)

- c. Set the oscilloscope to display a single pulse on the trace. Verify that the aberrations (overshoot, preshoot and ringing) are less than 5% of the ampli-

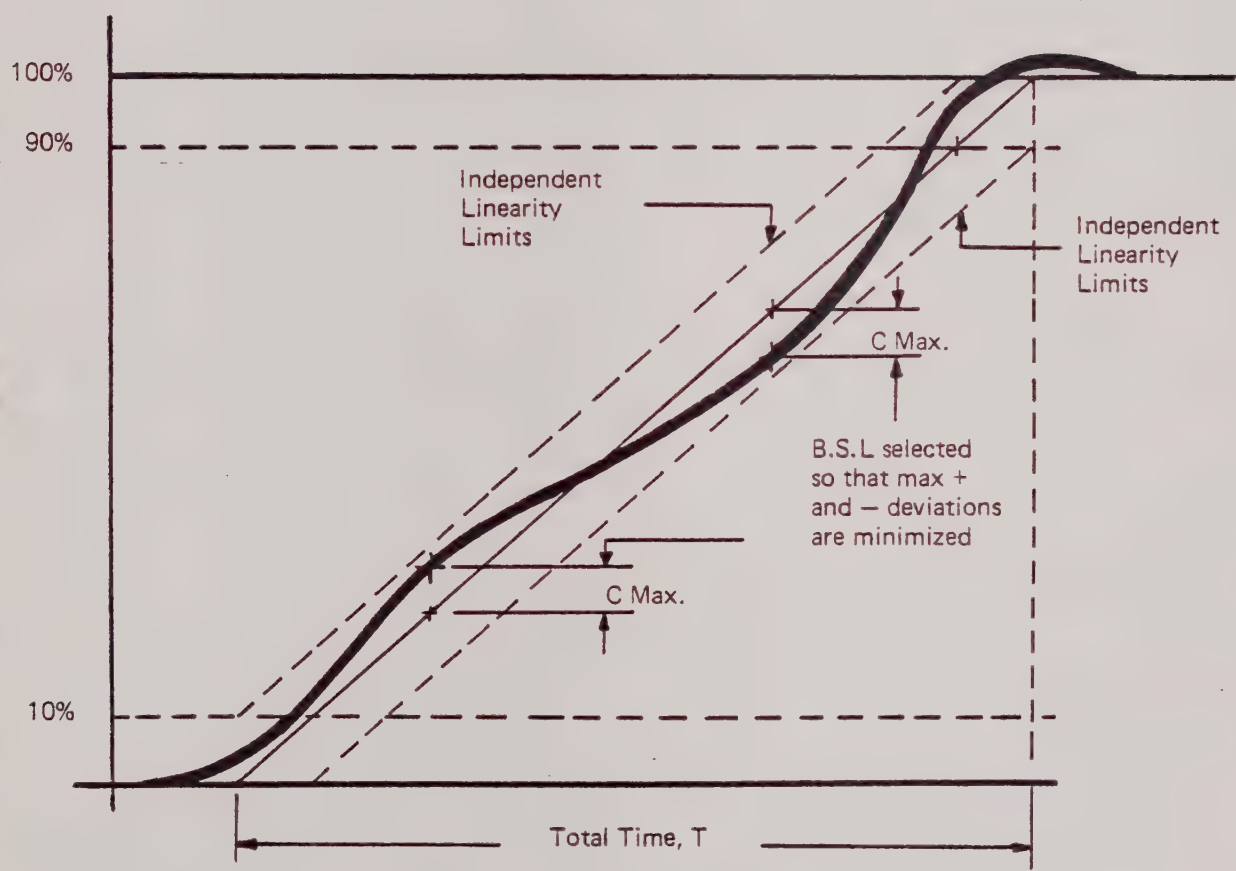


Figure 4-4. Linearity Characteristics

Table 4-4. Rise (T_+)/Fall (T_-) Time Checks

Thumbwheel Setting	Oscilloscope Indication*			
	1-10 μ s Rise/Fall Range	100-1000 ns Rise/Fall Range	10-100 ns Rise/Fall Range	5-10 ns Rise/Fall Range
100	0.95 to 1.05 μ s	95 to 105 ns	9.5 to 10.5 ns	
200	1.9 to 2.1 μ s	190 to 210 ns	19.0 to 21.0 ns	
300	2.85 to 3.15 μ s	285 to 315 ns	28.5 to 31.5 ns	
400	3.8 to 4.2 μ s	380 to 420 ns	38.0 to 42.0 ns	
500	4.75 to 5.25 μ s	475 to 525 ns	47.5 to 52.5 ns	5 ns $\pm 5\%$ +1 ns
600	5.7 to 6.3 μ s	570 to 630 ns	57.0 to 63.0 ns	5.7 to 6.3 ns
700	6.65 to 7.35 μ s	665 to 735 ns	66.5 to 73.5 ns	6.65 to 7.35 ns
800	7.6 to 8.4 μ s	760 to 840 ns	76.0 to 84.0 ns	7.6 to 8.4 ns
900	8.55 to 9.45 μ s	855 to 945 ns	85.5 to 94.5 ns	8.55 to 9.45 ns
999	9.5 to 10.5 μ s	0.95 to 1.05 μ s	95.0 to 105 ns	9.5 to 10.5 ns

*ALL READINGS ± 1 NS

tude (see Figure 4-5 for pulse characteristics).

- d. Set V_{UL} for +1.00 volt and verify that the aberrations are less than 5% of the amplitude.

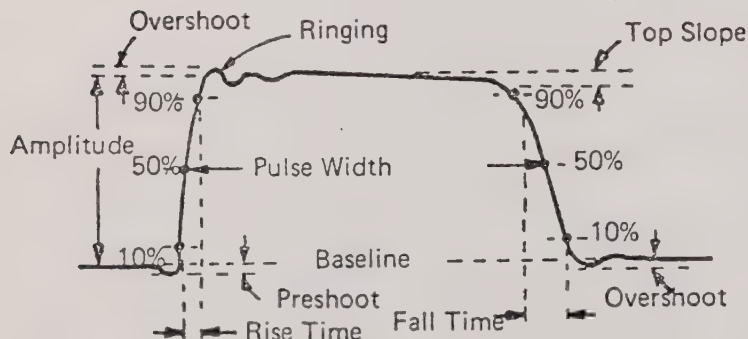


Figure 4-5. Pulse Characteristics

4.4.8 Jitter Check (Repetition Rate, Delay and Width)

- a. Set the instrument controls as follows:

Control	Setting
REP RATE	100 Hz (100-1000 Hz range)
DELAY	10.0 ns (10-100 ns range)
WIDTH	1.00 ms (1-10 ms range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	0.00 V (+1 V range)
RISE/FALL (Model 154-1 and 3)	5 ns (5-10 ns range)
MAN CONT	depressed
Remaining pushbuttons	released

- b. Monitor the OUTPUT with the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination at the oscilloscope. Trigger the oscilloscope from the TRIG OUT connector. Terminate with the 50 ohm, 2 watt termination at the oscilloscope.

- c. Set the oscilloscope controls to display several pulses on the trace. Select any two pulses and compute the percentage of jitter by the following equation:

$$\%Jitter = \frac{(J2-J1)}{T} 100$$

where J1 = leading edge jitter of the first pulse

where J2 = leading edge jitter of the second pulse

where T = time period between the leading edge of the first pulse and the leading edge of the second pulse (see Figure 4-6a).

- d. Verify that the repetition rate jitter is < 0.05% of 200 ps (whichever is greater). Check the repetition rate jitter at several points up to 1 MHz and verify that the jitter is < 0.05% or 200 ps (whichever is greater). Decrease the pulse width as required. Check the repetition rate jitter above 1 MHz on the sampling oscilloscope. Attenuate the output as required when using the sampling oscilloscope.
- e. Set the instrument the same as in step (a) except set the DELAY thumbwheels for 5.00 ms on the 1-10 ms range.
- f. Monitor the OUTPUT and the TRIG OUT on the dual-trace real-time oscilloscope. Trigger the oscilloscope with the leading edge of the TRIG OUT pulse. Set the oscilloscope controls to display one pulse on each trace.
- g. Compute the delay jitter by the following equation:

$$\%Jitter = \frac{(J2-J1)}{T} 100$$

where J1 = jitter on the leading edge of the TRIG OUT pulse

where J2 = jitter on the leading edge of the OUTPUT pulse

where T = the time period (delay) between the leading edge of the TRIG OUT pulse and the leading edge of the OUTPUT pulse (see Figure 4-6b).

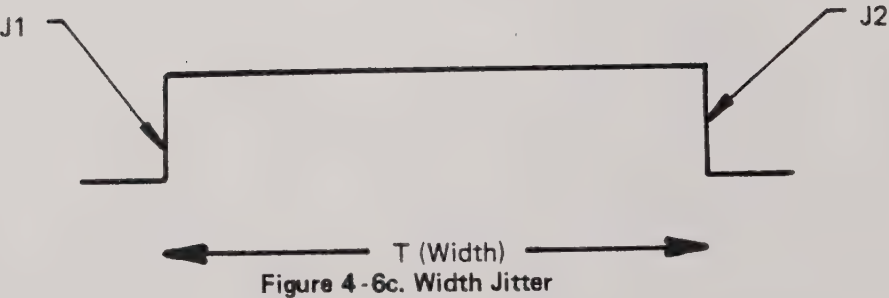
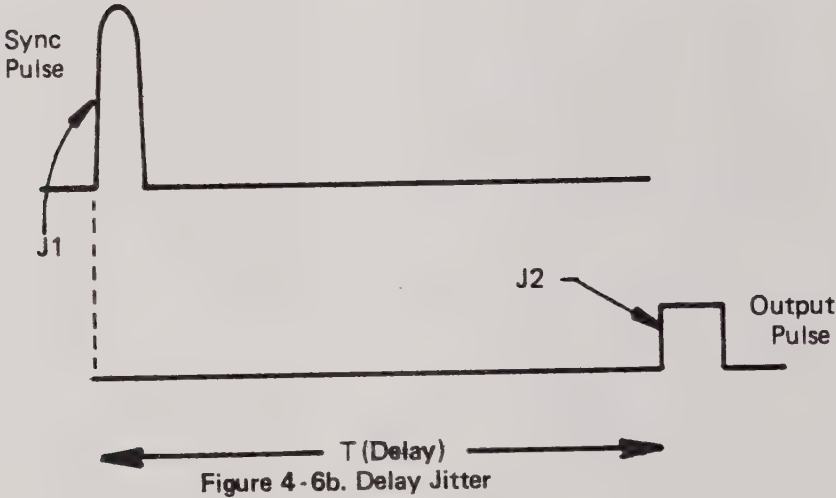
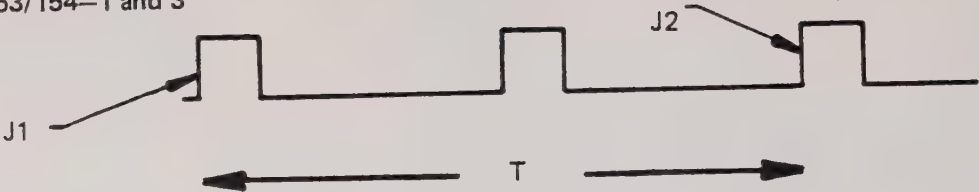
- h. Verify that the delay jitter is < 0.05% or 200 ps (whichever is greater). Check the jitter at several delay periods and verify that the jitter is < 0.05% or 200 ps (whichever is greater). Change the repetition rate as required to remain within the duty factor limitations listed in paragraph 3.1.1. Use the sampling oscilloscope to check the jitter for delay periods below 10 μs.
- i. Set the instrument the same as in step (a) except set the width for 5.00 ms on the 1-10 ms range.
- j. Monitor the OUTPUT on the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination. Trigger the oscilloscope internally on the leading edge of the pulse. Set the oscilloscope control to display a single pulse on the trace.
- k. Compute the width jitter by the following equation:

$$\%Jitter = \frac{(J2-J1)}{T} 100$$

where J1 = jitter of the pulse leading edge

where J2 = jitter of the pulse trailing edge

where T = pulse width (see Figure 4-6c).



- l. Verify that the width jitter is $<0.05\%$ or 200 ps (whichever is greater). Check the jitter at several pulse widths and verify that the jitter is $<0.05\%$. Change the repetition rate as required to remain within the duty factor limitations listed in paragraph 3.1.1. Use the sampling oscilloscope to check the jitter for pulse width below $10\mu\text{s}$.

4.4.9 External Trigger Check

- a. Connect the external trigger source to the TRIG IN connector. Set the trigger source for a repetition rate of 10 Hz, a width of 10 ns and an amplitude of +1 volt.
- b. Monitor the OUTPUT with the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination at the oscilloscope input. Trigger the oscilloscope from the TRIG OUT connector.
- c. Set the instrument controls as follows:

<u>Control</u>	<u>Setting</u>
WIDTH	10 ns (10–100 ns range)
DELAY	10 ns (10–100 ns range)
RISE/FALL (Model 154 only)	5 ns (5–10 ns range)
V _{UL}	+9.99 V (+10 V range)
V _{LL}	0.00 V (+1 V range)

- d. Depress the EXT TRIG AND TRIG POLARITY pushbuttons and verify that the instrument is triggered. Verify that the instrument can be triggered up to 50 MHz.

- e. Set the external trigger source for a -1 volt pulse and release the TRIG POLARITY pushbutton. Verify that the instrument can be triggered from 10 Hz to 50 MHz.

4.4.10 Gate Mode Check

- a. Connect the external gate source to the SYNC GATE connector. Set the gate source for a repetition rate of 50 kHz, a width of $100\mu\text{s}$ and a +1 volt amplitude.
- b. Set the instrument controls as follows:

<u>Control</u>	<u>Setting</u>
REP RATE	1.00 MHz (1–10 MHz range)
DELAY	10.0 ns (10–100 ns range)
WIDTH	10.0 ns (10–100 ns range)
V _{UL}	+9.99 V (+10 V range)
V _{LL}	0.00 V (+1 V range)

- c. Monitor the OUTPUT with the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination at the oscilloscope input. Trigger the oscilloscope from the sync output of the gate source.
- d. Depress the SYNC GATE pushbutton and verify that the output is gated (output occurs in groups of pulses at a 50 kHz rate and a duration of $100\mu\text{s}$). Release the SYNC GATE pushbutton.
- e. Disconnect the gate source from the SYNC GATE connector and connect it to the ASYNC GATE connector. Depress the SYNC GATE pushbutton and verify that the output is gated.

NOTE: The output will be unstable since the oscilloscope is being triggered from the gate source.

SECTION V

THEORY OF OPERATION

5.1 GENERAL DESCRIPTION

Refer to Block Diagram 41000 - 230 for the following explanation.

Time reference for the instrument is provided either by the rep rate multivibrator or an external trigger source. In the external trigger mode, the rep rate multivibrator is disabled. Pulses from the rep rate multivibrator, or the external trigger source, are standardized and shaped by a Schmitt trigger, then differentiated to drive the delay one-shot and the single/double pulse circuit. The differentiated pulses are also amplified and provided at the back panel as the trigger output.

The delay one-shot, a monostable multivibrator is shifted to its unstable state by each incoming trigger pulse. The output of the delay one-shot is delayed from the input by an amount determined by the front panel control or an external programming source. In the single pulse mode, the output of the delay one-shot drives the width one-shot. In the double pulse mode, the delayed pulse from the delay one-shot and the pulse from the trigger shaper drive the width one-shot. The resulting width one-shot output is two essentially identical pulses per repetition rate period, separated by the amount of set or programmed delay.

The width one-shot supplies two pulses of opposite polarity (for each input pulse) to the normal/complement circuit whose output supplies two pulses of opposite polarity to the rise and fall circuit. These two opposite polarity pulses switch a fixed current source (Model 153-1 and 3) or positive and negative variable current sources (Model 154-1 and 3) to charge the rise and fall capacitor in the rise and fall output circuit. The amplitude of the output pulse is determined by the upper level

(V_{UL}) and lower level (V_{LL}) voltages supplied by the V_{UL}/V_{LL} control to the rise and fall clamp diodes (CR433 and CR438). Power amplification of the pulse also takes place in the rise and fall output circuit.

When the complement mode is selected, the polarities of the pulses from the normal/complement circuit are reversed, resulting in the time position of the upper and lower levels of the output pulse being reversed. The transition times (T_+ and T_-) are reversed also in instruments with variable rise (T_+) and fall (T_-) times (Model 154-1 and 3).

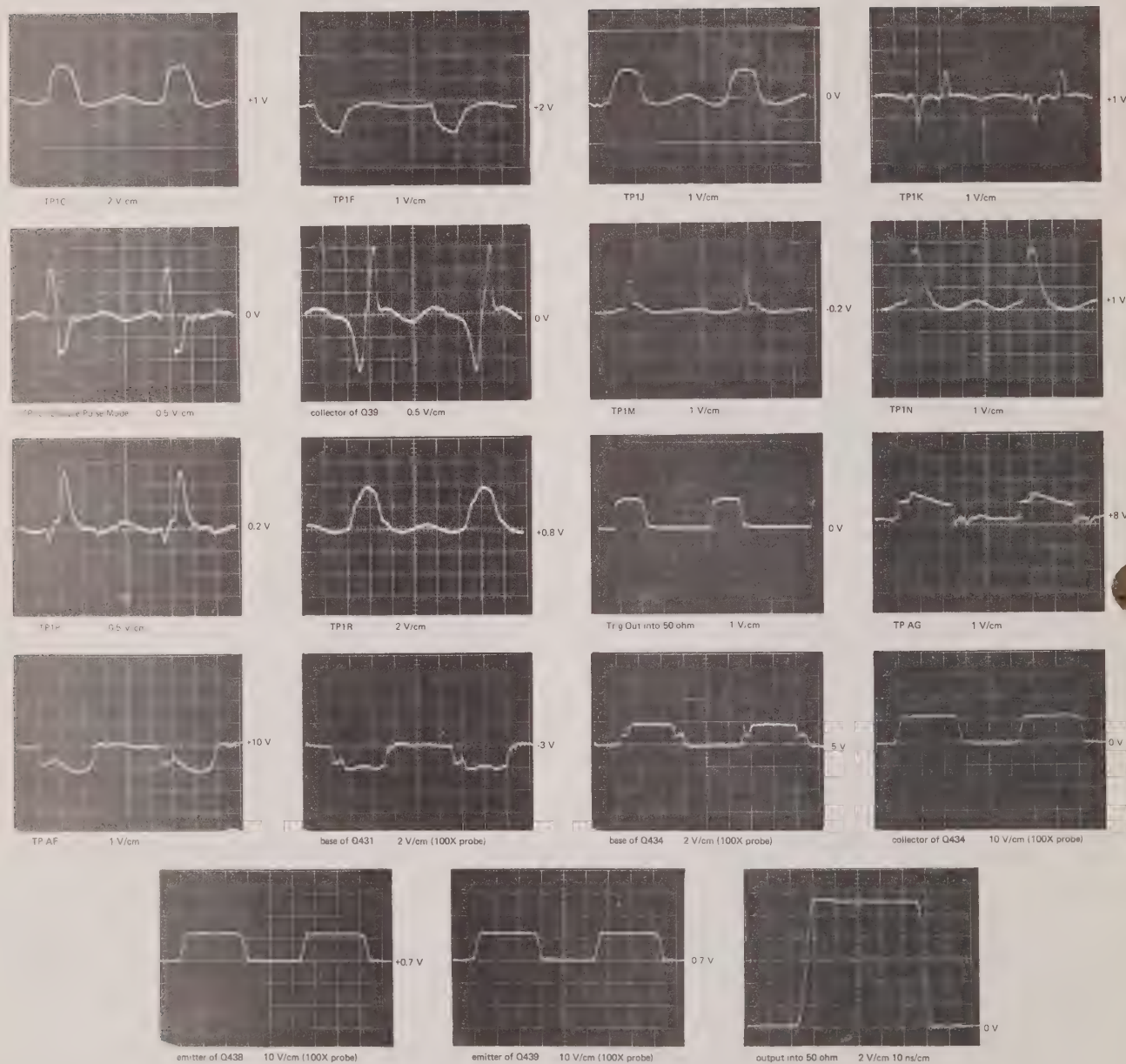
Selecting the synchronous gate mode disables the rep rate multivibrator. When the sync gate signal is applied, the rep rate multivibrator is enabled and continues to operate for the time interval of the gate signal and thus allows the output to occur for the same time interval. Synchronous gating results in an output that is synchronized with the gate signal. For asynchronous gating, the rep rate multivibrator is operative, however, the trigger pulses to the delay one-shot are blocked. The async gate signal enables the input to the delay one-shot for its duration and thus allows the output to occur for the same time interval. Asynchronous gating results in an output that is not synchronized with the gate signal.

5.2 DETAILED CIRCUIT DESCRIPTION

For paragraph 5.2.1 through 5.2.11 refer to Schematic 40000 - 421 and the applicable simplified schematic. Refer to Figure 5 - 1 for waveform photographs.

5.2.1 Repetition Rate Multivibrator

Figure 5 - 2 is a simplified schematic of the repetition rate multivibrator. Transistors Q10 and Q12 comprise the basic multivibrator. Range timing capaci-



Waveform photographs were taken with the following instrument setting:
 Rep Rate 10 MHz; Delay minimum; Width 50 ns; V_{HL} +10 V; V_{LL} 0 V.
 Oscilloscope used: Sampling oscilloscope with 10X probe unless otherwise
 specified. Horizontal setting 20 ns/cm unless otherwise specified

Figure 5-1. Waveform Diagrams

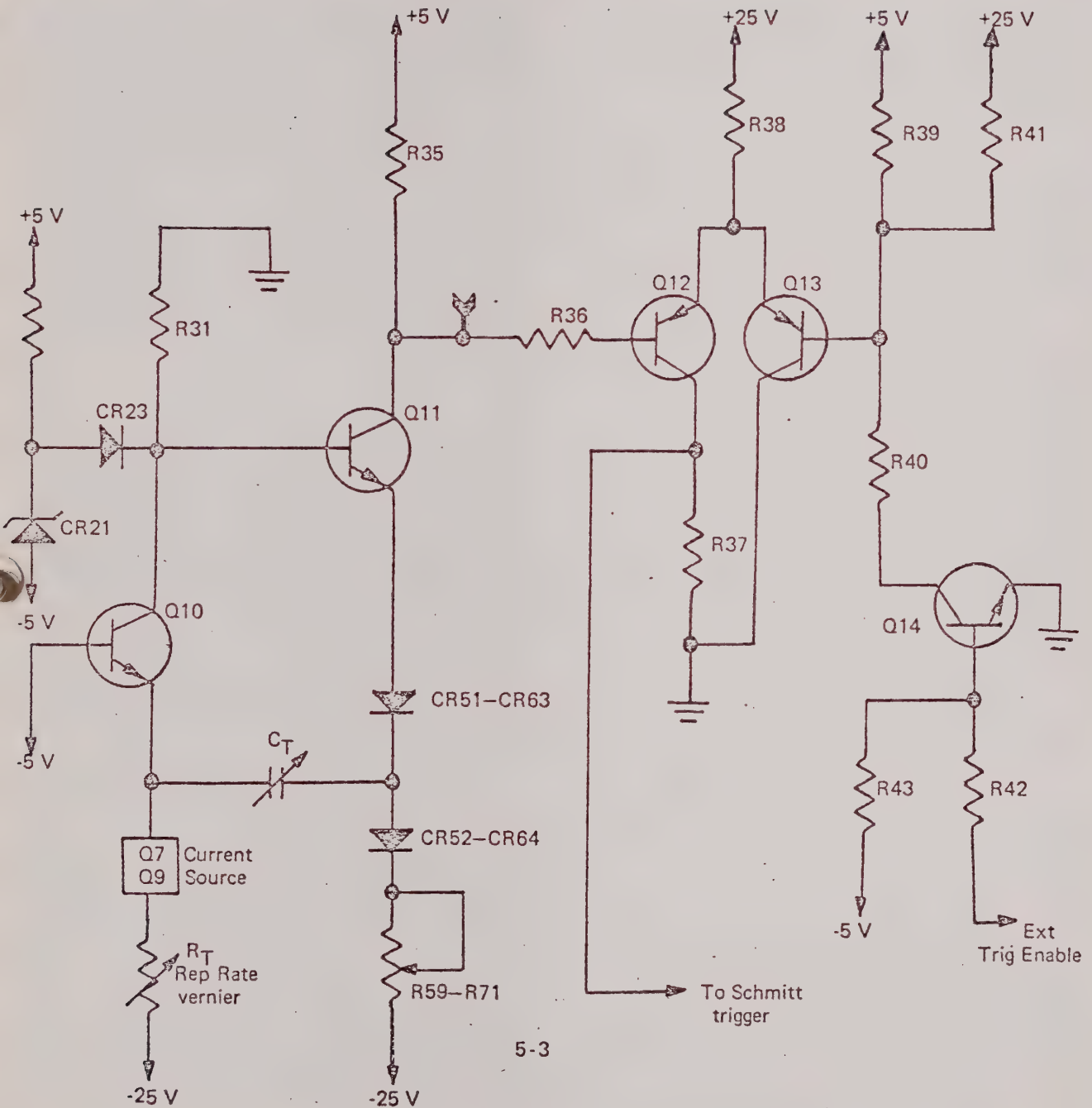


Figure 5-2. Rep Rate Multivibrator

tors, C52 through C61, represented by C_T in the simplified schematic, are located in the repetition rate decoder. Potentiometer R_T represents either the programming source vernier control or the front panel thumbwheels.

Transistors Q10 and Q11 are alternately turned on and off by feedback through timing capacitor C_T . At initial power on, either transistor may be conducting, therefore, for purposes of analysis, assume that Q10 has just turned off. Its collector and consequently the base of Q11 are at ground which causes Q11 to conduct. The current (from the current source) which formerly flowed through Q10, begins to charge C_T . The charging of C_T causes the emitter of Q10 to go negative. When the voltage is negative enough to forward bias Q10, it conducts. Both the collector of Q10 and the base of Q11 are driven sharply negative when Q10 conducts. Since the voltage across C_T cannot change instantaneously, the emitter of Q11 does not follow the base and Q11 remains cut off. Timing capacitor C_T , at the emitter of Q11 begins to discharge through one of the range resistors, R59—R71, depending on which range is selected. When the emitter of Q11 reaches approximately 0.6 V below the base voltage, it comes on again.

Diode CR23 clamps the collector of Q10 at approximately -3 volts and therefore prevents it from saturating. The current source for the repetition rate multivibrator is comprised of transistors Q7 and Q9. Potentiometer R21 is the zero frequency adjust and R32 is the maximum frequency adjust.

5.2.2 Schmitt Trigger

Trigger pulses either from an external source or from the repetition rate multivibrator are standardized into rectangular pulses, then differentiated and developed into a sharp positive spike by the Schmitt trigger. This sharp spike is used to drive the delay one-shot.

The incoming trigger pulses are fed to emitter follower Q30 then level detected by Z2.

Uniform negative and positive rectangular pulses are developed at the outputs of Z2, pins 1 and 2. The positive-going rectangular pulse at pin 1 of Z2 is divided by the voltage divider comprised of R142 and R152 and coupled back to one of the inputs (pin 4) to establish the hysteresis of the level detector. The negative-going rectangular pulse at pin 2 is coupled to the input of the external trigger out amplifier.

Differential amplifier, Q31/Q32, R145 and L140 differentiate the rectangular pulse and at the collector of Q31 produces a negative-going spike followed by a positive-going spike. Only the negative spike causes Q33 to conduct, thereby developing a positive spike at its collector.

5.2.3 External Trigger

The external trigger circuit disables the output of the repetition rate multivibrator whenever external triggering is selected. When the instrument is in the internal trigger mode, Q18 supplies base current to Q21 which saturates and reverse biases CR86 and CR87. This prevents the output of differential amplifier Z2 from being coupled to the input of the Schmitt trigger. Also in the internal trigger mode, Q14 is on, making the base of Q13 approximately +4 volts. The pulse from the repetition rate multivibrator turns Q12 off when its base exceeds +4 volts and the pulse at the collector of Q12 is coupled through CR140 to the input of the Schmitt trigger.

External triggering is enabled when 0 volts is applied at circuit point **B5**. Transistors Q14 and Q18 are both turned off by this voltage. With Q14 off, the base of Q13 is at approximately +5.6 volts and the amplitude of the pulse from the repetition rate multivibrator does not go positive enough to turn Q12 off. Therefore, the collector of Q12 does not swing far enough in a negative direction to forward bias CR140 thereby preventing the repetition rate multivibrator output from triggering the Schmitt trigger. With Q18 off, CR86 or CR87 (depending on the trigger polarity) is forward biased, thus allowing the external trigger pulses to be coupled to the Schmitt trigger input.

Positive trigger polarity is enabled by applying 0 volts to circuit point (B7). This voltage turns Q19 and Q20 on and Q22 off. The conduction of Q19 reverse biases CR87 and the conduction of Q20 biases pin 11 of differential amplifier Z2 so that when a positive trigger is applied at the trigger input, the output is coupled through CR86 to the Schmitt trigger input. Negative triggering is enabled by applying +5 volts to circuit point (B7). Under this condition, Q22 is on and Q19 and Q20 are off. The conduction of Q22 reverse biases CR86 and with Q20 off, pin 11 of differential amplifier Z2 is biased so that when a negative trigger is applied at the trigger input, the output at pin 13 is coupled through CR87 to the Schmitt trigger input.

5.2.4 Sync Gate

When synchronous gating is enabled the current source for the repetition rate multivibrator is diverted from the timing capacitor until the application of the sync gate pulse.

To enable synchronous gating, Q2 is turned off and Q3 is turned on by applying 0 volts at circuit point (B4). With transistor Q3 on, base current is supplied to Q5 which conducts and supplies emitter current for differential amplifier Q1/Q4. The left hand half of the differential amplifier Q1 is conducting with no sync pulse applied since its base is more negative than the base of Q4. The conduction of Q1 forward biases Q6 which conducts and diverts the current source for the repetition rate multivibrator to ground.

When the sync gate pulse is applied to the sync input, Q1 is turned off, which turns Q6 off and the current source is allowed to flow to this timing capacitor.

5.2.5 Async Gate

The async gate circuit is comprised of differential amplifier Z2B and gate enable transistor Q24. When asynchronous gating is enabled, the Schmitt trigger output is blocked until the application of the gate signal.

In non-gated operation, transistor Q8 is biased on by the high state (approximately +2 volts) of differential amplifier Z2B. When async gating is enabled, transistor Q24 is biased on. With Q24 conducting, the input at pin 5 of Z2B is approximately ground, resulting in the output at pin 8 being approximately -0.5 volts. Transistor Q8 is then turned off and the base of Q32 is biased to +1.5 volts. Therefore the trigger at the base of Q31 does not have enough amplitude to overcome the bias at the base of Q32. Applying a positive gate signal to the async gate input turns Q8 on for the time interval of the gate signal and the trigger is passed by differential amplifier, Q31/Q32.

5.2.6 Trigger Out Amplifier

The trigger output amplifier is comprised of two stages of differential amplification, separated by a delay line and an emitter-follower output.

The rectangular pulse from the output of Z2C (pin 2) is differentiated by C120 and R121. The negative-going (leading edge) spike is amplified by differential amplifier Q25/Q26. However, the positive-going (trailing edge) spike is rejected since Q26 is already off. The amplified spike from Q26 is delayed by delay line DL120 and inverted by differential amplifier Q27/Q28. The positive-going spike at the emitter of Q29 is coupled to the back panel as the trigger output.

5.2.7 Delay One-Shot

Figure 5 - 3 is a simplified schematic of the delay one-shot. Transistor array Z3 is an integrated circuit, therefore transistor reference designations are assigned to facilitate the explanation.

The basic circuit of the delay one-shot is a monostable multivibrator. When the one-shot is triggered by a positive pulse it shifts to its unstable state and remains there for the length of time determined by the timing capacitor and the setting of the delay vernier.

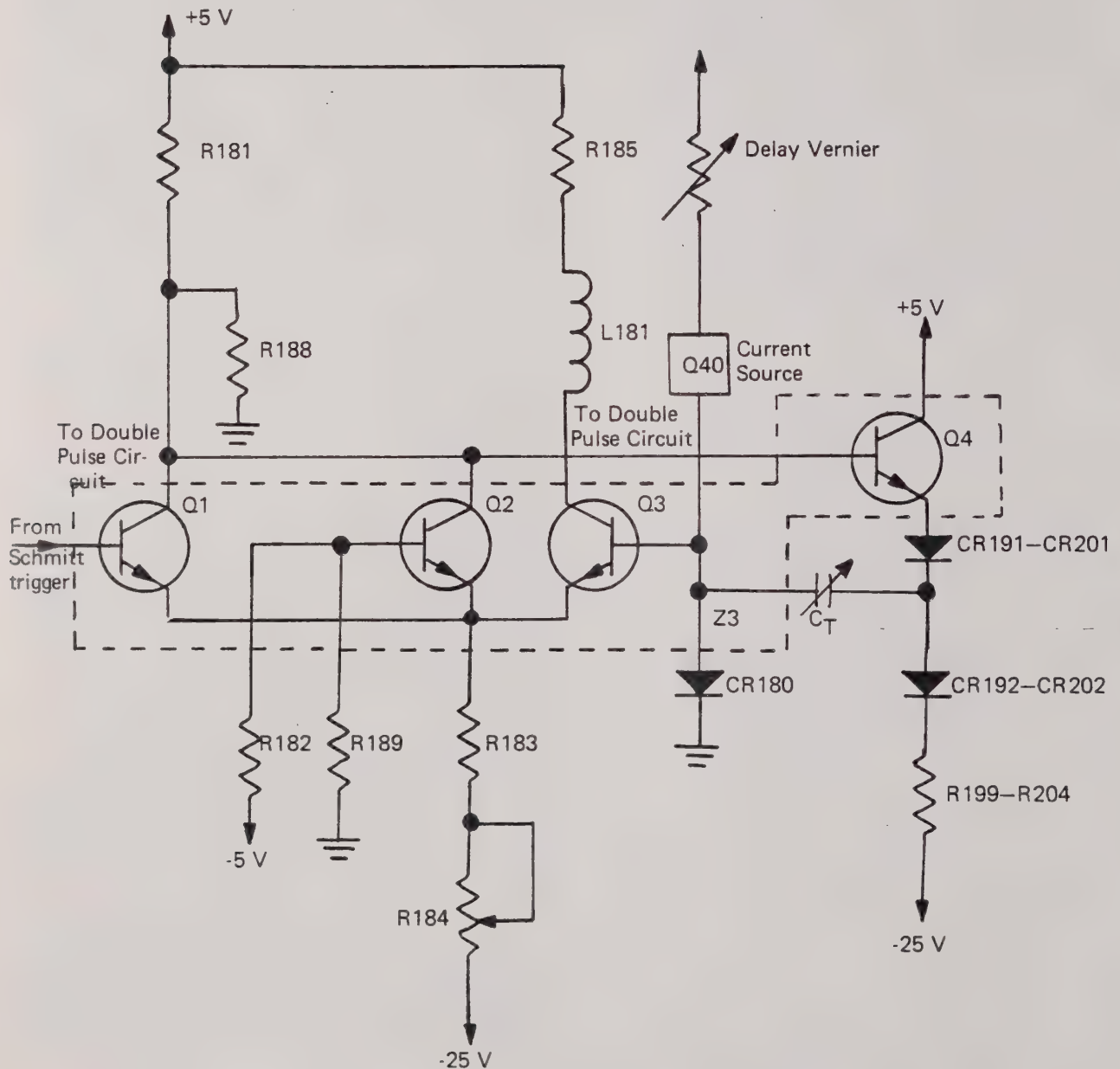


Figure 5-3. Delay One-Shot

Between pulses, Q1 is off and Q3 is on since its base is at approximately 0.6 volts. The positive pulse from the Schmitt trigger turns Q1 on, developing a negative-going pulse at its collector which is coupled through Q4 and C_T to the base of Q3. Transistor Q3 is turned off by this pulse and remains off while current source Q40 charges C_T positively. When the charge on C_T is positive enough to forward bias Q3, it turns on and Q1 turns off in preparation for the next trigger. During the cycle of operation a negative-going rectangular pulse is produced at the collector of Q1, a positive rectangular pulse at the collector of Q3. The time interval between the leading and the trailing edge of the pulse corresponds to the set delay.

Diode CR180 establishes the bias on Q3. Potentiometer R184 is the maximum delay calibration adjustment and L181 equalizes the width of the pulse at the collector of Q3 with the width of the pulse at the collector of Q1.

5.2.8 Double Pulse

The double pulse circuit is comprised of differential amplifier Q38/Q39 and logic transistors Q35 through Q37. The function of this circuit is to develop two sharp positive pulses; one at the beginning of the delay period and the other occurring at the end of the set delay period. In the single pulse mode only the delayed pulse drives the width one-shot, however, in the double pulse mode both the delayed and undelayed pulse drives the width one-shot.

The two rectangular pulses from the delay one-shot (negative at the base of Q38 and positive at the base of Q39) simultaneously turn transistor Q38 on and Q39 off. The pulses developed at the collectors of Q38 and Q39 are differentiated by L160/R165 and L161/R166 respectively. Diodes CR162 and CR163 allow only the positive spikes of the differentiated pulses to be coupled to the input of the width one-shot. The positive spike on the collector of Q38 occurs at the beginning of the delay period and the positive-going spike at the collector of Q39 occurs at the end of the delay period.

Single pulse mode is enabled by forward biasing Q37 with +5 volts at circuit point **(CO)**. With Q37 conducting, both Q36 and Q35 are turned on. The collector current in Q35 causes a voltage drop of approximately -0.6 volts across CR160. This voltage drop reverse biases CR161 and blocks the pulse on the collector of Q38.

5.2.9 Width One-Shot

The width one-shot is a monostable multivibrator that operates the same as the delay one-shot. The period of time that it remains in its unstable condition corresponds to the set pulse width. Rectangular pulses are developed at pins 1 and 5 of Z5. These pulses drive the normal/complement amplifier.

5.2.10 Normal/Complement Amplifier

The normal/complement amplifier, comprised of differential amplifiers Q49/Q51 and Q50/Q52 and logic transistors Q48, Q53 and Q54, determines the polarity of the main output pulse by switching the polarity of the pulses at circuit points **(AF)** and **(AG)**.

When the normal mode is enabled Q54 is turned on by +5 volts at circuit point **(B8)**. With Q54 conducting, base current is supplied to Q53 which conducts and supplies emitter current to differential amplifier Q50/Q52. The conduction of Q53 also makes the voltage at the base of Q48 approximately -25 volts which prevents it from conducting. The positive and negative pulse at the bases of Q50 and Q52 respectively, simultaneously turn Q50 on and Q52 off, thereby developing a negative-going pulse at circuit point **(AG)** and a positive-going pulse at circuit point **(AF)**.

In the complement mode, Q54 is turned off by 0 volts at circuit point **(B8)**. With Q54 not conducting, Q53 is off and Q48 is on since it is forward biased by the voltage developed by the voltage divider consisting of R252 and R253. The positive pulse at the base of Q51 turns it off, resulting in a negative-going pulse at circuit point **(AF)** and a positive-going pulse at circuit point **(AG)**.

Transistor Q55 is a voltage source that supplies collector voltage for Q49 through Q52 and bias voltage for the input stage of the output amplifier.

5.2.11 Rep Rate, Width and Delay Decoder

The operation of the three decoders are identical. The decoders determine which timing capacitor is utilized in the multivibrator circuit. A three digit BCD input to the three input transistors enable the logic circuit (Z1, Z4 or Z6) which selects the timing capacitor and resistor. Refer to Figure 2-2 or 2-3 for the BCD inputs.

5.2.12 V_{UL}/V_{LL} Control

Refer to Schematic 40000 - 412 and Figures 5 - 4 and 5 - 5 for the following explanation.

The V_{UL}/V_{LL} control circuit develops the upper and lower level voltage for the clamp diodes in the output amplifier and thereby control the amplitude of the output pulse. Both V_{UL} and V_{LL} are variable from 0 to +10 volts or 0 to -10 volts. Since the operation of the V_{UL} and V_{LL} circuits are the same, only the V_{UL} circuit will be explained.

The input for the V_{UL} circuit is at the emitter of Q1. This positive input voltage from the V_{UL} D/A converter causes emitter current to flow in Q1 since its base is at approximately 3.2 volts. When the V_{UL} D/A converter is set for maximum upper level voltage (10 volts) the input to Z1 pin 5 is approximately 3.5 volts. Since Z1 is connected as a voltage follower, the output amplitude is the same as the input. This voltage is amplified by Z91, which has a gain of approximately 3 or -3, depending on the range selected. The polarity of the output voltage from Z91 is determined by whether the input voltage is to pin 4 (inverting input) or pin 5 (non-inverting input).

Figure 5 - 4 shows a simplified schematic of the range and polarity selection portion of the

V_{UL}/V_{LL} control circuit. Range and polarity selection is accomplished by setting the program lines according to the truth table on Schematic 40000-412. Logic circuit Z41 turns on the corresponding transistor for the range selected. Figure 5-5 shows the configuration of operational amplifier Z91 and the equations for each V_{UL} range and polarity.

Transistors Q91 and Q92 protect Z91 from excess current drain. Diode CR101 compensates for the voltage drop in the clamp diode in the output amplifier. Zener diode CR99, diode CR100 and the base-emitter junctions of Q91, Q92, Q111 and Q112 limit the maximum difference between V_{UL} and V_{LL} to approximately 11.5 volts. Diodes CR93 through CR98 protect against damage in case V_{LL} is set more positive than V_{UL} .

5.2.13 Variable Rise/Fall Power Supply (Model 154 only)

5.2.13.1 General Description

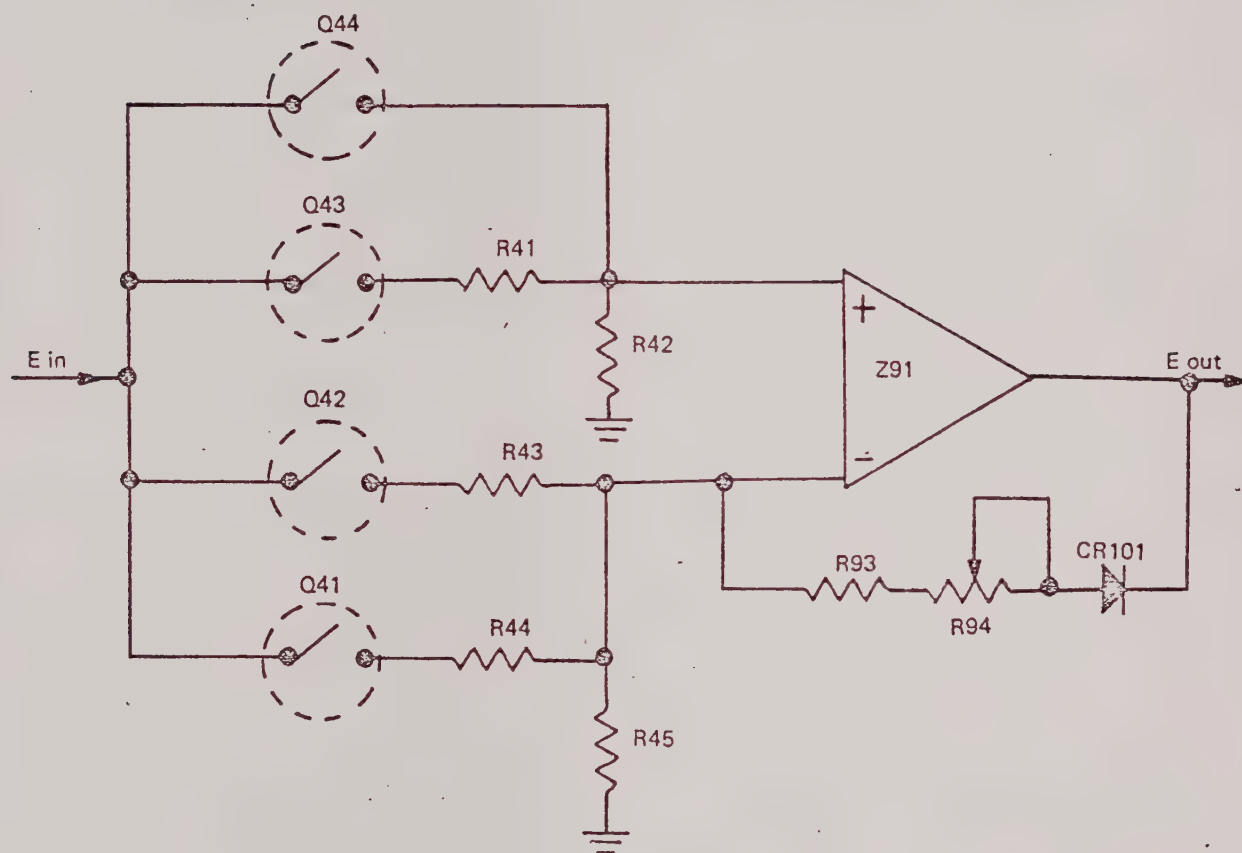
Refer to Schematic 40000-551 and simplified Block Diagram, Figure 5 - 6 for the following explanation.

The rise/fall power supply develops the charging current for the rise/fall capacitors in the output amplifier. Only the differences between the fall and rise time sections will be discussed as the circuits operate in a similar manner (the rise time circuit supplies positive current and the fall time circuit supplies negative current).

The inputs from the D/A cards are in the form of a conductance which varies proportional to the digital word. The other inputs are V_{UL} and V_{LL} , signals which vary with output amplitude settings.

The combination of these signals causes the rise and fall times to remain constant with amplitude (refer to the simplified presentation of the rise/fall circuit shown in Figure 5-6a).

Assuming a positive charge cycle, the voltage V_c will start at approximately V_{LL} and increase

Figure 5-4. V_{OL} Range and Polarity Selection Circuit

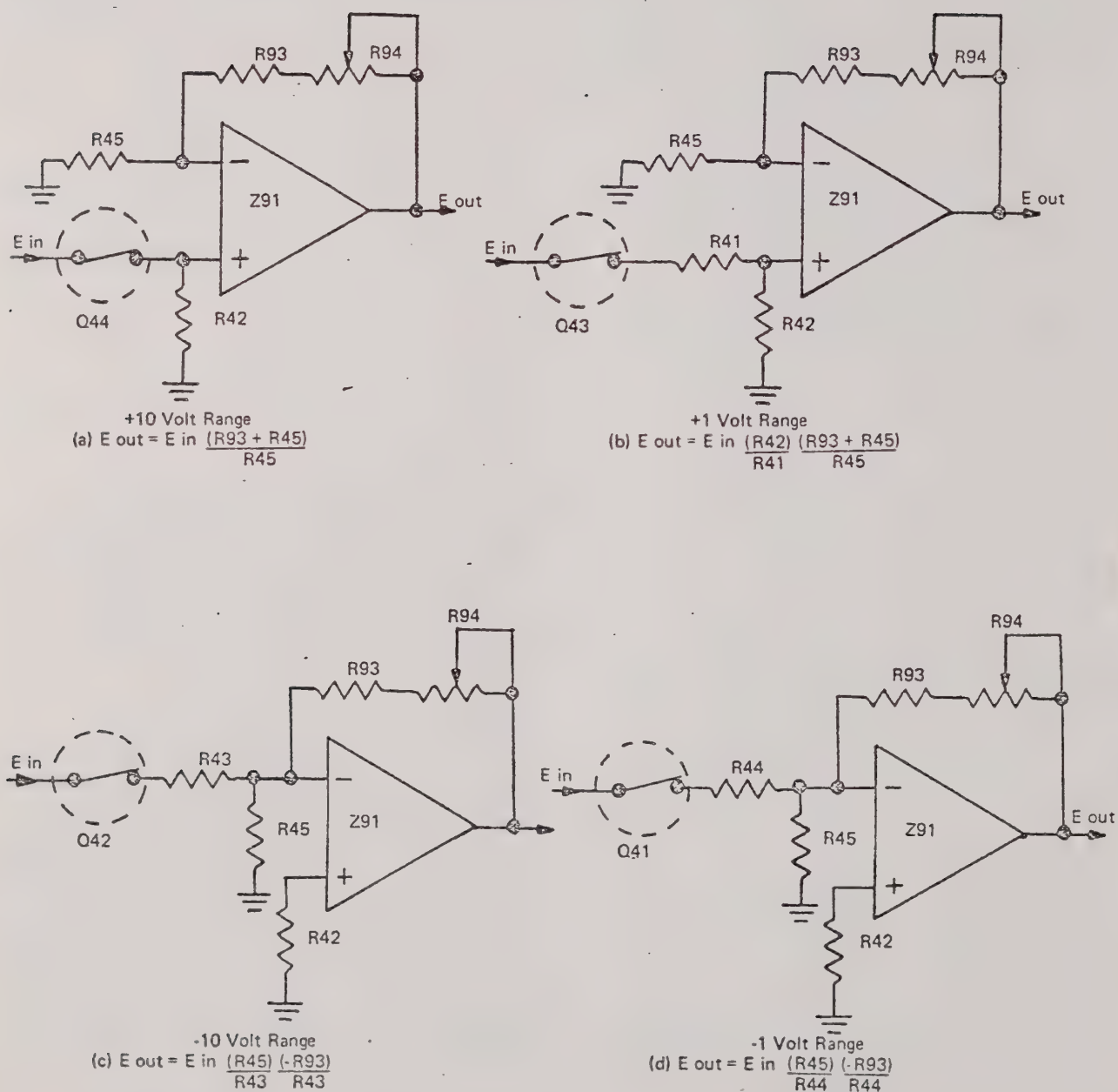


Figure 5-5. Detailed Range and Polarity Selection Circuit

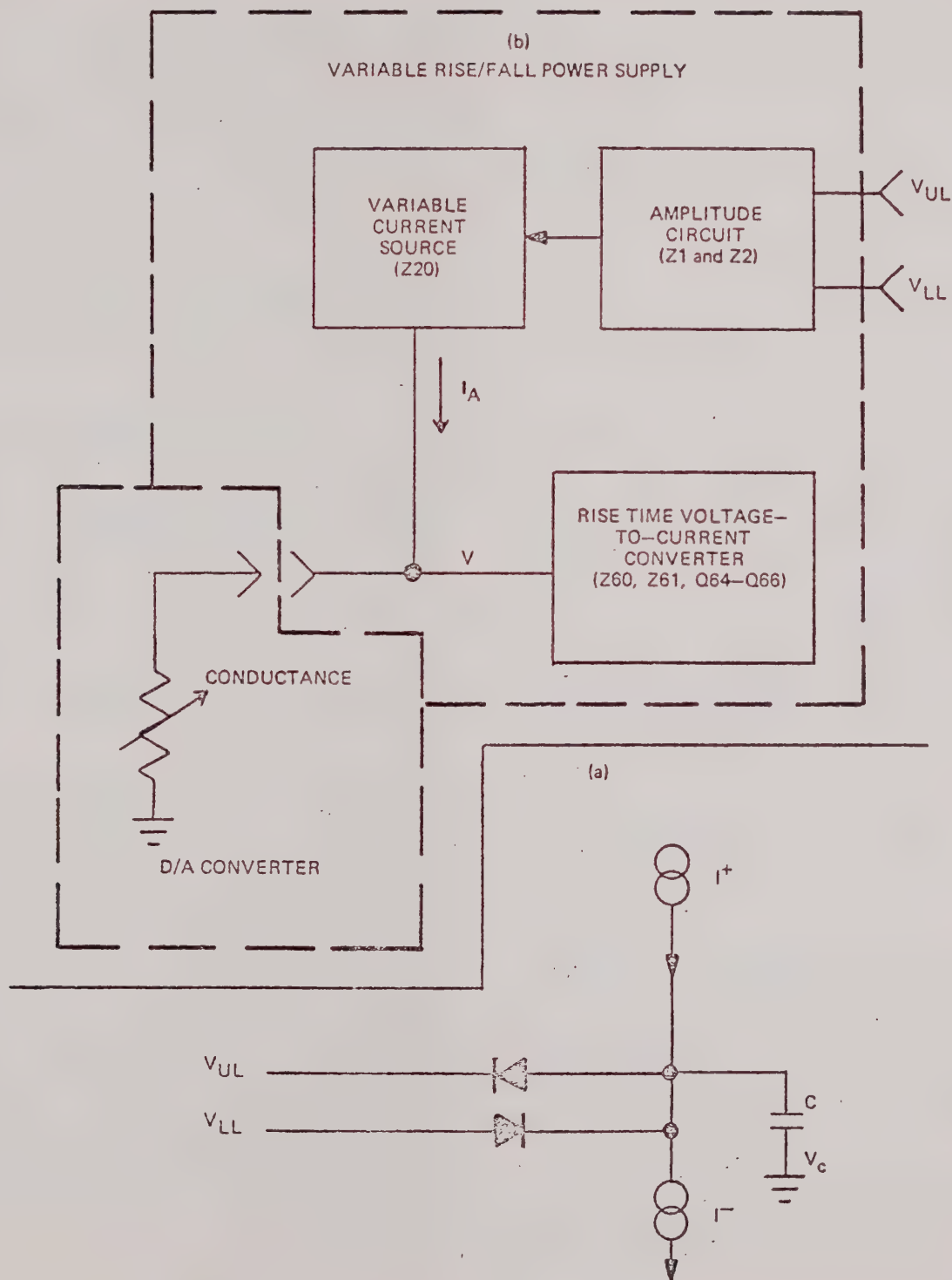


Figure 5-6. Simplified Block Diagram

until the V_{UL} voltage level (approximately) is reached. The charge rate is determined by the current I_+ .

The charge time then is (for I_+ constant):

$$T_+ = V_C \times C / I \text{ (equation 1)}$$

To keep T_+ constant, I_+ must vary proportionally to V_C ($I_+ \propto V_C$).

The rise/fall power supply accomplishes the function of keeping I_+ constant (as shown in Figure 5-6b).

The V_{UL} and V_{LL} signals are subtracted ($V_{UL} - V_{LL}$) to give a signal proportional to amplitude. This signal is fed into a current source, causing its current output to vary proportional to the amplitude of the input from Z2. This current drives a resistance (R) on the D/A card to develop a voltage delivered to the current converter and thus provides I_+ to the output amplifier.

The resistance (R) is inversely proportional to the time (T_+) selected by the program (or front panel), thus the voltage $V = I_A R$ is also inversely proportional to the setting.

I_+ is then developed by the voltage to current converter and $I_+ \propto I_A R$ substituting in equation (1), we develop a new expression:

$$T_+ \propto (V_C \times C) / I_A R \text{ (equation 2)}$$

As $V_C \propto$ amplitude and $I_A \propto$ amplitude, T_+ then becomes proportional to C and R , only.

$$T_+ \propto C / R \text{ (equation 3)}$$

As $1/R$ is proportional to settings and C is constant,

$$T_+ \propto \text{setting} \text{ (equation 4)}$$

and therefore the rise time is independent of amplitude.

5.2.13.2 Detailed Circuit Description

Refer to Schematic 40000 - 551 and the simplified schematic in Figure 5-6 for the following explanation.

The inputs to the R/F power supply include V_{UL} and V_{LL} and the rise time and fall time signals. Any variation in these inputs results in variations in the voltage level applied to the Rise and Fall Time Voltage to Current Converters, with a resultant change in charging current supplied to the capacitors in the Rise/Fall Output Amplifier.

Differential amplifier Z1 compares the V_{UL} and V_{LL} inputs and develops an output proportional to the difference between these two inputs. The output of Z1 drives operational amplifier Z2; Z2 sets the scale factor and bias level of the signal driving variable current source Z20 (observable at TP3). Changes in the output level of Z2 cause Z20 to change the level of its current output (measured across R21 between TP1 and TP2).

The current output of Z20 develops a voltage across the conductance selected on the D/A converter card (paragraph 5.2.16 and 5.2.17).

This voltage (determined by the value of the selected conductance and the current from Z20) is supplied to pin 5 of the operational amplifier Z60 in the Rise Time Voltage to Current Converter.

Changes in voltage sensed at pin 5 of Z60 are amplified by Z60 and coupled through Q61 to operational amplifier Z61, which keeps the voltage at the emitter of Q65 at the proper level. This voltage determines the emitter and collector current of Q65 which supplies the rise time current output to the output amplifier. Transistor Q66 supplies current to diode CR101 in the V_{UL}/V_{LL} control circuit that is proportional (approximately one half) to the current supplied to the output amplifier. This current keeps the voltage drop across CR372 approximately equal to the drop across the clamp diode (R62/CR63) in the output amplifier.

For the 5–10 ns rise/fall time range, Q63 is held in a conducting state by a positive voltage from the output amplifier (through pin U of the Bay 2 connector). When the 5–10 ns range is selected, Q63 is turned on, thereby lowering the collector voltage of Q61, thus increasing the output current of Q65. In all other ranges Q63 is turned off.

Differences existing between the Rise Time and Fall Time Voltage to Current Converters will now be defined. Z80 is a voltage following buffer, Q80 provides temperature and offset compensation for the Hyperbolic Conductance D/A Card. Z81 performs the same function as Z60 except that it inverts to provide negative current. The remainder of the Fall Time Voltage to Current Converter circuitry is essentially the same as that of the Rise Time Voltage to Current Converter except that all transistors are of opposite polarity due to the requirement for opposite currents.

5.2.14 Fixed Rise/Fall Output Amplifier (Model 153)

Refer to Schematic 40000 - 436 for the following explanation.

The output amplifier develops the amplitude and rise/fall times of the output pulse. The inputs to the output amplifiers at J425 and J426 are the timing pulses from the front end board (circuit points **AF** and **AG**). Diodes CR438 and CR433 are clamped by the upper level (V_{UL}) and lower level (V_{LL}) voltages respectively.

Transistors Q426 and Q430 are alternately turned off and on by the timing pulse from the front end board and Q427 and Q429 (connected in a cascade arrangement with Q426 and Q430) are driven by the pulse at the collectors of Q426 and Q430. The collector swing on Q434 is limited by clamp diodes CR433 and CR438. The current that determines the rise and fall times is supplied by the current source comprised of Q432 and Q435. This current is proportional to the difference between

the upper level voltage at the base of Q425 and a compensated lower level voltage ($V_{LL}-5$ volts) at the base of Q428.

The amplitude of the pulse at the junction of the clamp diodes (CR438 and CR433) is approximately at the level of the output pulse. Aberrations are removed from the pulse top by operating parallel emitter followers, Q436/Q438 or Q437/Q439 (depending on the pulse polarity) near saturation. Parallel transistor combinations Q442/Q444 and Q441/Q443 are the current sources for the parallel emitter followers. Base voltage for the current sources is supplied by upper level (V_{UL}) and lower level (V_{LL}) voltages. Transistors Q448 and Q449 limit the current to complementary output transistors Q446 and Q447.

Collector voltage for Q427 and Q429 and emitter voltage for Q442 and Q444, which is $V_{LL}-5$ volts, is developed by diode CR439 and zener diode CR440 and supplied at the emitter of Q440. Emitter voltage for Q441 and Q442, and base voltage for Q433 which is $V_{UL}+5$ volts, is developed by diode CR436 and zener diode CR437 and supplied at the emitter of Q445. Diodes CR450 through CR452 and CR455 through CR457 are part of the overvoltage protection circuit described in paragraph 5.2.12. They prevent damage if the upper and lower levels are set more than 11.5 volts apart.

5.2.15 Variable Rise/Fall Output Amplifier (Model 154)

Refer to Schematic 40000 - 438 for the following explanation.

The output amplifier develops the amplitude and rise/fall times of the output pulse. The inputs to the output amplifier at J1 and J2 are the timing pulses from the front end board (circuit points **AE** and **AG**). Diodes CR62/CR63 and CR64 are clamped by the upper level (V_{UL}) and lower level (V_{LL}) voltage respectively, thereby determining the upper and lower levels of the output pulse.

Transistors Q11 and Q12 are alternately turned off and on by the timing pulses from the front

end board. Differential amplifiers Q13/Q14 and Q15/Q16 alternately drive current switching amplifiers Q18/Q19 and Q20/Q21 respectively to develop the rise/fall times of the pulse. Current sources Q22 and Q17 supply the positive and negative current to charge the rise/fall time capacitors (C4, C5, C7, C8, C10 and C11). The amount of current flowing in these two sources is determined by the rise/fall power supply (see paragraph 5.2.12).

The heart of the output amplifier (the rise/fall circuit) is illustrated in simplified form in Figure 5-7. When the polarity of timing pulses are as shown in Figure 5-7, Q18 and Q21 are conducting. The rise/fall timing capacitor (C4/5, C7/8 or C10/11) is charged negatively by the current through Q21. When the voltage on the capacitor goes negative enough to forward bias clamp diode CR64, the charging current is shunted through the diode. The capacitor maintains the negative charge until the polarity of the timing pulses change at which time transistors Q19 and Q20 are turned on. With Q20 on, the timing capacitor is charged in a positive direction until clamp diode CR62/CR63 is forward biased.

The amplitude at the junction of clamp diodes CR62/CR63 and CR64 is approximately at the level of the output pulse. Aberrations are removed from the pulse top by operating emitter-follower Q27 or Q26 (depending on the pulse polarity) near saturation. Transistor combinations Q24/Q25 and Q28/Q29 are the current sources for emitter-followers Q26 and Q27. Base voltage for these current sources is supplied by the upper and lower level voltages. Transistors Q33 and Q36 supply the current to complementary output transistors Q34 and Q35.

Collector voltage V_{UC} ($V_{UL} + 5$ volts) for differential amplifiers Q13/Q14 is developed by diode CR83 and zener diode CR82 and supplied at the emitter of Q23. Collector voltage V_{LC} ($V_{LL} - 5$ volts) for differential amplifiers Q15/Q16 is developed by diode CR92 and zener diode CR93 and supplied at the emitter of Q30. Diodes CR101

through CR106 are part of the overvoltage protection circuit described in paragraph 5.2.12. They prevent damage if the upper and lower levels are set more than 11.5 volts apart.

The alternate charging of the timing capacitor develops the pulse as shown at point A.

Selection of the rise/fall range is accomplished by turning on either Q6, Q8 or Q10 thereby supplying a charging path for the timing capacitor on the collector. The 5–10 ns range has no range capacitor. An explanation of how the 10–100 ns range is selected will serve to illustrate the operation of the logic circuit.

In order to select the 10–100 ns range 0 volts is applied at line 1 and +5 volts at line 11. Under this condition, transistor Q1 is biased off and Q3 is biased on. With Q1 off, Q2 is conducting and with Q3 conducting Q4 is off. Therefore, the cathode of the gate diodes will be as follows: CR9 and CR10 both +5 volts; CR11 and CR12 both ground; CR13 ground and CR14 +5 volts. With the gate diodes in this voltage configuration, Q8 and Q10 are off and Q6 is on, supplying a charging path for capacitor C5, thereby selecting the 10–100 ns range.

5.2.16 Hyperbolic D/A Converter (Schematic 40000-482)

The hyperbolic D/A converter shown in simplified form in Figure 5-8 changes the 12-bit digital inputs into current levels required by the delay and width circuits. Each of the 12-bits set the state of switching transistors Q2–Q24 (even numbers). When the bit is true the transistor is on and its collector resistor is placed in parallel with resistors R65 and R66. Current source Q27 supplies current to this parallel combination. Since operational amplifier Z8 is connected as a comparator, the voltage drops across the parallel combination and R71/R72 are equal and the amount of current that flows through R71/R72 is proportional to the current that flows through Q28 to the D/A converter output.

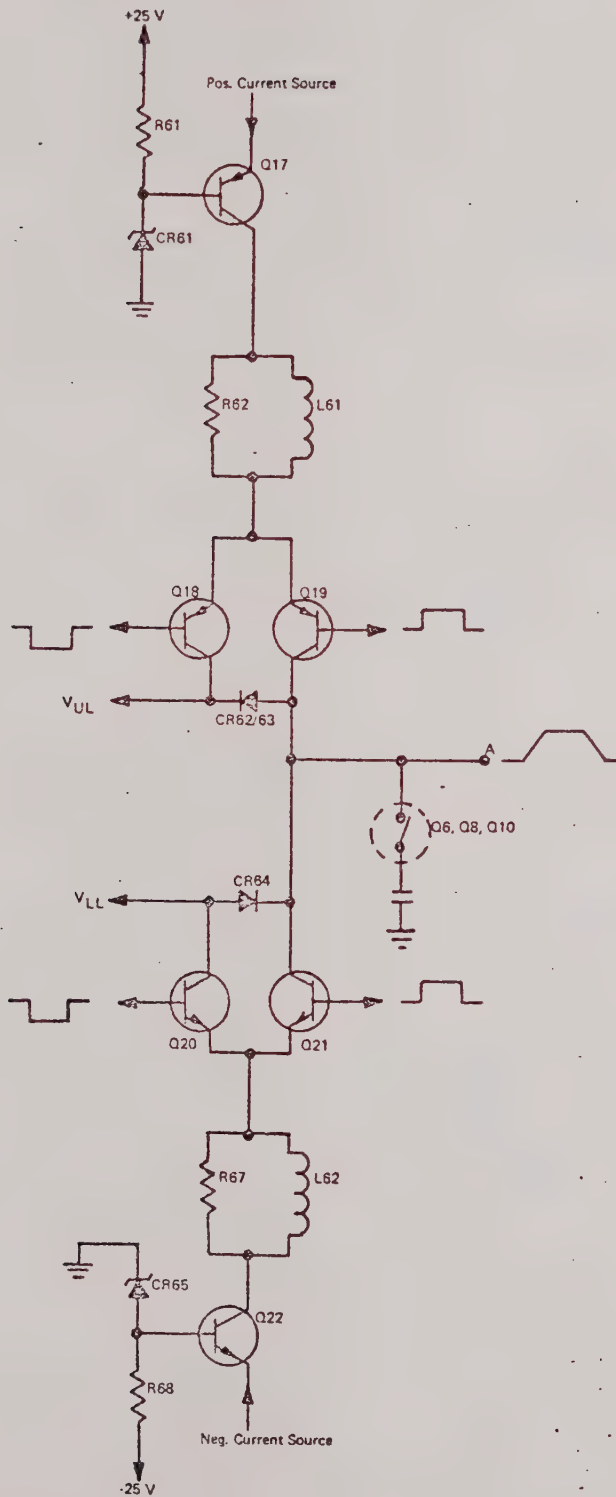


Figure 5-7. Rise/Fall Output Amplifier Circuit

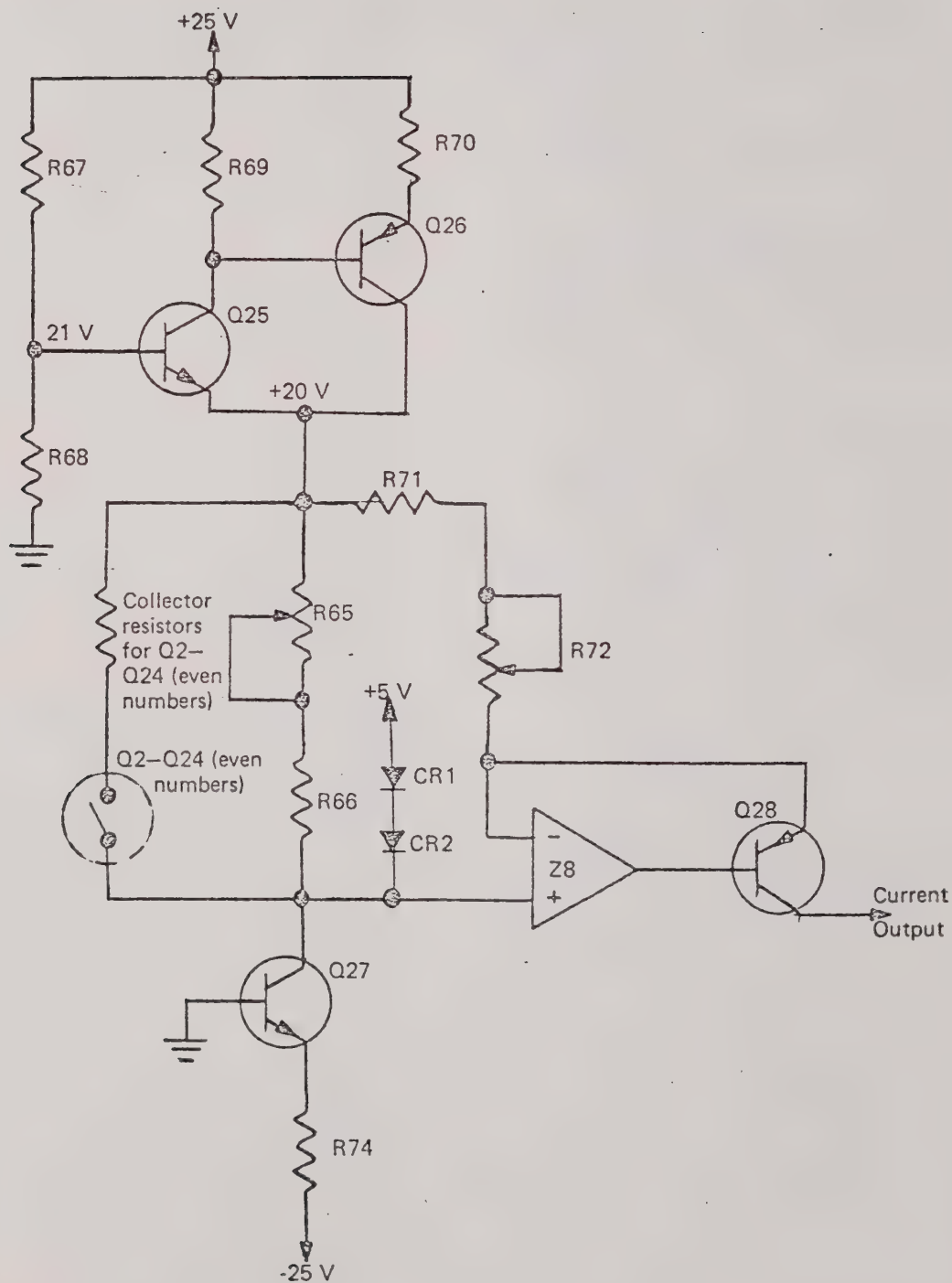


Figure 5-8. Hyperbolic D/A Converter

Transistors Q25 and Q26 comprise a voltage source that supplies approximately 20 volts at R71. Clamp diodes CR1 and CR2 prevent pin 5 of Z8 from going below 3 volts. Diodes CR3 and CR4 prevent Z8 from latching up.

In instruments that have serial data inputs, bi-stabled latches Z4–Z7 hold switching transistors Q2–Q24 in the state determined by the data inputs. The bi-stable latches are enabled by strobe A and B. When the instrument is controlled by the front panel switches, +5 V AUTO is removed thereby disabling Z4–Z7.

In instruments that have parallel data inputs, line drivers Z1–Z3 actuate switching transistors Q2–Q24.

5.2.17 Hyperbolic Conductance D/A Converter

Refer to Schematic 40000 - 550 for the following explanation.

The hyperbolic conductance D/A converter changes the 12-bit (3-digit BCD) digital input into a conductance (1/resistance) proportional to the digital word. Each of the 12-bits sets the state of a switching transistor (Q1 through Q12) into BCD format. When the input bit to converters Z8 or Z9 is true (ground), the corresponding transistor is turned on, and the associated conductor is essentially grounded. The number of transistors turned on determines the value of conductance obtained.

As an example, if the MSD were 1 the transistor Q1 would be on and the conductance would be approximately 1/10.2 k. If the MSD were 2, Q2 is on and the conductance is approximately 1/5.1 k. Thus it can be seen that the value of conductance was doubled (the resistance halved) illustrating the proportionality of the conductance and thus the inverse (hyperbolic) proportionality of the resistance.

In instruments that have serial data inputs, bi-stabled latches Z4–Z7 hold switching tran-

sistors Q2–Q24 in the state determined by the data inputs. The bi-stable latches are enabled by strobe A and B. When the instrument is controlled by the front panel switches, +5 V AUTO is removed thereby disabling Z4–Z7.

In instruments that have parallel data inputs, line drivers Z1–Z3 actuate switching transistors Q2–Q24.

5.2.18 Linear D/A Converter

Refer to Schematic 40000 - 481 for the following explanation.

The linear D/A converter changes the 12-bit digital inputs into current levels required by the repetition rate multivibrator and V_{UL}/V_{LL} control circuit. The switching transistors (Q1–Q12) are on when the data bit is false. When the data bit is true the switching transistor is off. The number of transistors that are not conducting determines the amount of current that flows in the output.

5.2.19 Serial to Parallel Converter (Model 153/154-3)

The serial to parallel converter receives 12 line serial data from the programming source, and through the use of addresses, programs each pulse parameter and selects the mode of operation.

The eight data bits are fed through line drivers, Z1, Z2 and Z3 to the data inputs of the D/A converter (see Schematic 40000 - 487). The four address bits and the clock input enable quad-NAND gate Z5 which drives BCD-to-decimal decoders Z7 and Z8. The decoded outputs Z7 and Z8 are inverted and become the strobes for the parameter selected by the address.

The clock input is delayed approximately 200 ns by one-shot multivibrator Z6 and is fed to rear panel connector J1 as delayed clock out.

5.2.20 Power Supply

Refer to Schematic 40000 - 417 for the following explanation.

The power supply consists of two nearly identical regulators, +25 and -25 volts, a +5 volt regulator that also supplies +2 volts and a -5 volt regulator. All of the voltage sources are series regulated, and all operate approximately the same. Therefore only the +25 volt regulator will be explained.

Rectified and filtered voltage is supplied to the collector of Q502. Reference for the regulator is provided by zener diode Z501 and R510 is adjusted so that the inputs to error amplifier Z501

are equal. Any errors occurring at the supply output is sensed across R510, resulting in a voltage change in the opposite polarity at the output of Z501. Assuming that the output voltage has decreased (gone negative) the voltage at the output of Z501 increases (goes positive). This positive-going voltage increases the current through series pass transistors Q502 and Q503 which cause the output voltage to increase.

Over-current protection is provided by transistor Q504. When an over-current condition occurs, Q504 is forward biased by the voltage drop across R504. Transistor Q504 conducts and the over-current is shunted away from the series pass transistors. When the over-current condition is removed the regulator is restored to normal operation.

CHAPTER 6

REPLACEABLE PARTS

6.1 INTRODUCTION

This chapter contains the spare parts lists for each assembly in the Models 153/154-1, 3 and 4 Pulse Generator. Chapter 7 shows the schematics where the listed parts are installed. Ordering information is included and should be used when purchasing parts from the factory. Explanation of the column listings and Table 6-1 Manufacturers Code-To-Name Index are also included.

6.1.1 Reference Designations

Reference designations in this parts list correspond to the circuit symbols used in the following schematics.

Drawing Numbers:

40000-421	40000-436	40000-483
40000-412	40000-438	40000-486
40000-558	40000-481	40000-487
40000-444	40000-482	40000-417
40000-551	40000-550	057887

6.2 PART ORDERING INFORMATION

To order a part from the Replaceable Parts List, state the Systron-Donner part number, indicate the quantity required and address the order to the nearest Systron-Donner Sales or Service Center.

To order a part not listed in the Replaceable Parts List, state the instrument model number, instrument serial number, the description and function of the part, and the number of parts required. Address the order to the nearest Systron-Donner Sales or Service Center.

6.3 PARTS LISTS

Table 6-1 gives the code-to-name information for the manufacturers listed in the replaceable parts lists. The replaceable parts lists are placed in a numbered sequence.

Each column in the parts lists provides specific information relating to the listed parts as follows:

(1) DESIGNATOR: Reference numbers applicable to assemblies are listed in alphanumeric order.

(2) COMPONENT NOMENCLATURE AND DESCRIPTION: Component names and specifications are provided in these columns and include; value, tolerance, wattage rating, working voltage, construction, etc.

(3) MANUFACTURER'S CODE: H4-2 Federal Supply Code numbers are listed to identify component manufacturers. A Manufacturers Index is provided in this chapter for cross-reference.

(4) MANUFACTURER'S PART NUMBER: True manufacturer part numbers are listed in this column.

(5) SD STOCK NUMBER: The Systron-Donner stock number is listed in this column.

(6) T/Q (Total Quantity): This quantity, appearing after an item entry, indicates the number of times the component is used in that assembly. The total quantity for each part is given only once - at the first appearance of the part number is the list.

TABLE 6-1 MANUFACTURER'S CODE-TO-NAME INDEX

CODE	NAME & ADDRESS	CODE	NAME & ADDRESS
00779	Amp-Inc P.O. Box 3608 Harrisburg, PA 17105	09353	C and K Components Inc. 103 Morse Newton, MA 02158
00853	Sangamo Electric Co. So. Carolina Division P.O. Box 128 Pickens, SC 29671	14099	Semtech Corp. 652 Mitchell Rd. Newbury Park, CA 91320
01121	Allen-Bradley Co. 1201 So. 2nd St. Milwaukee, WI 53204	14752	Electro Cube Inc. 1710 So. Del Mar Ave. San Gabriel, CA 91776
01295	Texas Instruments Inc. Semiconductor & Components Div. 13500 No. Central Expressway Dallas, TX 75231	15818	Teledyne Semiconductor 1300 Terra Bella Ave. Mountain View, CA 94040
02114	Ferroxcube Corp. P.O. Box 359 Mt. Marion Rd. Saugerties, NY 12477	15915	Tepro of Florida Inc. 2608 Enterprise Rd. Dunedin, FL 33528
02735	RCA Corp. Solid State Division Route 202 Somerville, NJ 08876	16299	Corning Glass Works Electronic Components Div. 3900 Electronics Drive Raleigh, NC 27604
03508	General Electric Co. Semiconductor Products Dept. Electronics Park Syracuse, NY 13201	16733	Phelps Dodge Communications Co. Div. of Phelps Dodge Copper Prod. North Haven, CT 06473
03797	Genisco Tech. Corp. Eldema Division 18435 Susana Rd. Compton, CA 90221	19701	Mepco/Electra Inc. Electra Divsio P.O. Box 760 Mineral Wells, TX 76067
03877	Transitron Electronic Corp. 168 - 186 Albion St. Wakefield, MA 01880	26466	Carter Electronics Corp. 6762 Greenville Ave. Dallas, TX 75231
04713	Motorola Semiconductor Prod. Inc. 5005 E. McDowell Rd. Phoenix, AZ 85008	26654	Varadyne Inc. Capacitor Division 2110 Broadway Santa Monica, CA 90404
05245	Corcom Inc. 2857 No. Halsted St. Chicago, IL 60657	27556	IMB Electronic Prod. Inc. 15401-E Carmenita Rd. Santa Fe Springs, CA 90670
07263	Fairchild Camera & Instrument Corp Semiconductor Division 313 Frontage Road Mountain View, CA 94040	28480	Hewlett-Packard Co. 1501 Page Mill Rd. Palo Alto, CA 94304
		29309	Richey Electronics Inc. P.O. Box 8274 1305 Dickerson Rd. Nashville, TN 37207

TABLE 6-1 MANUFACTURER'S CODE-TO-NAME INDEX (Cont'd)

CODE	NAME & ADDRESS	CODE	NAME & ADDRESS
31433	Union Carbide Corp. Components Dept. Highway 276 S.E. Greenville, SC 29606	78553	Tinnerman Products Inc. 8700 Brookpart Rd. Cleveland, OH 44129
44655	Ohmite Mfg. Co. 3601 W. Howard St. Skokie, IL 60076	81312	Litton Industries Inc. Winchester Electronics Div. Main St & Hillside Ave. Oakville, CT 06779
52542	Systron-Donner Corp. Instrument Division 10 Systron Drive Concord, CA 94518	81349	MIL STD
56289	Sprague Electronic Co. North Adams, MA 01247	82389	Switchcraft Inc. 5555 N. Elston Ave. Chicago, IL 60630
71400	Bussmann Mfg. Div. of McGraw-Edison Co. 2536 W. University St. St. Louis, MO 62017	82647	Texas Instrument Inc. Control Products Division 34 Forest St. Attleboro, MD 02703
71590	Globe-Union Inc. Centralab Electronics Div. 5757 No. Green Bay Ave. Milwaukee, WI 53201	88245	Litton Systems Inc. USECO Division 13536 Saticoy St. Van Nuys, CA 91409
72136	Electro Motive Mfg. Co. Inc. South Park & John Sts. Willimantic, CO 06226	91418	Radio Materials Co. 4242 W. Bryn Mawr Chicago, IL 60646
72169	Dialco 60 Stewart Ave. Brooklyn, NY 11237	91637	Dale Electronics Inc. P.O. Box 609 Columbus, NE 68601
72982	Erie Technological Products Inc. 644 W. 12th St. Erie, PA 16512	92702	IMC Magnetics Corp. Eastern Division 570 Main St. Westbury Long Isoand, NY 11591
73138	Beckman Instruments Inc. Helipot Division 2500 Harbor Blvd. Fullerton, CA 92634	96906	MIL STD
75915	Littlefuse Inc. 800 E. Northwest Hwy. Des Plains, IL 60016	99392	S T M Corp. 2904 Chapman St. Oakland, CA 94601
78189	Illinois Tool Warks Inc. Shakeproof Division St. Charles Rd. Elgin, IL 60120	99800	American Precision Industries Inc. Delevan Division 270 Quaker Rd. E. Quorora, NY 14052
		99848	Wilco Corp. 10th Street Indianapolis, IN 46222

REPLACEABLE PARTS LIST

TITLE						
FRONT PANEL ASSEMBLY						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
		ASSEMBLY, Model 153-1 Front Panel	52542	37000946	37000946	1
		ASSEMBLY, Model 153-3 Front Panel	52542	37000168	37000168	1
		ASSEMBLY, Model 154-1 Front Panel	52542	37000948	37000948	1
		ASSEMBLY, Model 154-3 Front Panel	52542	057754	057754	1
		ASSEMBLY, Model 154-4 Front Panel	52542	057754	057754	1
1		PANEL, Front	52542	32001168	32001168	1
2		PLATE, Face Model 153-4 Only	52542	32001446	32001446	1
2		PLATE, Face Model 154-4 Only	52542	057977	057977	1
3		ASSEMBLY, Switch Cable	52542	057773	057773	1
4		TRIM, End	52542	32001286	32001286	2
5		TRIM, Front	52542	32001203	32001203	2
6	DS1	LAMP, Cartridge	72619	507-3917-1472-600	106896	1
7	S501	SWITCH, SPDT	09353	7101	102310	1
9		CLIP, Speed	03797	Q-081-905	106977	1
10		TERMINAL, Insulator 4-40	88245	1417A-7	106989	2
11	F502	FUSE, 1.5A	75915	315-01.5	106917	1
12		NUT, Kep 4-40	78189	511-041800-00	100941	2
13		SCREW, FHMS 8-32 x 1/2	96906	MS24693-C272	10074308	4
14		SCREW, FHMS 6-32 x 1/4	96906	MS24693-C24	10073104	8
15		SCREW, PHMS 4-40 x 5/16	96906	MS51957-14	10062605	2
16		SCREW, FHMS 4-40 x 3/16	96906	MS24693-C1	10072003	2
17		WASHER, Split-Lock #4	96906	MS35338-135	100711	2
18		NUT, Hex 2-56	96906	MS35649-224	100636	4
19		WASHER, Flat #4	96906	MS15795-802	100614	4
20		WASHER, Split-Lock #2	96906	MS35337-77	100661	4
21		NUT, Speed 6-32	78553	C1887-632-4	102944	8
22		WASHER, Int. Tooth #4	96906	MS35333-70	100794	2

REPLACEABLE PARTS LIST

TITLE						
AUXIAIARY SWITCH ASSEMBLY #37001-082						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	CR731	DIODE, Silicon	07263	1N4150/1N3600	112127	7
	CR732	Same as CR731				
	CR733	Same as CR731				
	CR734	Same as CR731				
	CR735	Same as CR731				
	CR736	Same as CR731				
	CR737	Same as CR731				
	S730 thru S737	ASSEMBLY, Switch 8-Bank	52542	106817	106817	1

REPLACEABLE PARTS LIST

TITLE						
FRONT END PC ASSEMBLY #37000-914						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	C1	CAPACITOR, Ceramic .022 μ F 20%, 25V	71590	2DDU60E223M	106483	39
	C2	Same as C1				
	C20	Same as C1				
	C21	Same as C1				
	C22	Same as C1				
	C23	CAPACITOR, Tant 47 μ F 20%, 20V	56289	196D476X020LA1	106514	3
	C24	Same as C1				
	C25	Same as C23				
	C26	CAPACITOR, Tant 100 μ F 20%, 10V	05245	TK3010-107-20	106511	1
	C27	Same as C1				
	C50	Same as C1				
	C51	Same as C1				
	C52	CAPACITOR, DM 22 pF 5%, 500V	72136	DM15ED220JO	100068	3
	C53	CAPACITOR, Variable 2.5-11 pF, 200V	72982	538-014-90B	106499	3
	C54	CAPACITOR, DM 220 pF 5%, 500V	72136	DM15FD221JO	100220	1
	C55	CAPACITOR, Variable 15-60 pF, 200V	72982	538-011F15-60	100234	3
	C56	CAPACITOR, DM 3000 pF 1%, 500V	00853	CD19FD302F	112296	1
	C57	CAPACITOR, Mylar .033 μ F 2%, 200V	27556	ZA2C333G	106423	3
	C58	CAPACITOR, Mylar .033 μ F 2%, 200V	14752	210B1C334G	106424	3
	C59	CAPACITOR, Tant 3.3 μ F 5%, 35V	31433	K3R3C35D	106534	3
	C61	CAPACITOR, Tant 33 μ F 5%, 10V	56289	150D336X5010B2	106533	1
	C63	Same as C23				
	C80	CAPACITOR, DM 1000 pF 5%, 100V	72136	DM15FA102JO	100243	2
	C81	Same as C1				
	C82	Same as C1				
	C83	Same as C1				

REPLACEABLE PARTS LIST

TITLE						
FRONT END PC ASSEMBLY #37000-914 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	C84	Same as C1				
	C85	Same as C1				
	C101	Same as C1				
	C120	CAPACITOR, DM 100 pF 5%, 500V	72136	DM15FD101JO	100173	1
	C121	Same as C1				
	C122	Same as C1				
	C123	Same as C1				
	C124	Same as C1				
	C125	Same as C1				
	C126	CAPACITOR, DM 15 pF 5%, 500V	72136	DM15CD150JO	100241	2
	C140	Same as C1				
	C141	Same as C1				
	C142	Same as C1				
	C144	CAPACITOR, Tant 6.8 μ F 20%, 35V	56289	196D685X0035KE1	106515	2
	C145	Same as C144				
	C160	Same as C1				
	C180	Same as C1				
	C181	Same as C1				
	C182	Same as C1				
	C190	Same as C1				
	C191	Same as C1				
	C192	Same as C53				
	C193	CAPACITOR, DM 300 pF 5%, 500V	72136	DM15FD301JO	102577	2
	C194	Same as C55				
	C195	CAPACITOR, DM 3300 pF 1%, 500V	72136	CM06F332F03	112295	2
	C196	Same as C57				
	C197	Same as C58				
	C198	Same as C59				
	C200	Same as C1				
	C209	Same as C126				
	C210	Same as C1				
	C211	Same as C80				

REPLACEABLE PARTS LIST

TITLE						
FRONT END PC ASSEMBLY #37000-914 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	C212	Same as C1				
	C213	Same as C1				
	C214	Same as C1				
	C230	Same as C1				
	C231	Same as C52				
	C232	Same as C53				
	C233	Same as C193				
	C234	Same as C55				
	C235	Same as C195				
	C236	Same as C57				
	C237	Same as C58				
	C238	Same as C59				
	C240	Same as C1				
	C250	Same as C1				
	C251	Same as C1				
	C252	Same as C1				
	C253	Same as C1				
	CR1	DIODE, Silicon	07263	1N4150/1N3600	112127	64
	CR2	Same as CR1				
	CR20	Same as CR1				
	CR21	DIODE, Zener 3.3V	03877	1N746A	100415	1
	CR22	Same as CR1				
	CR23	DIODE, Signal 10V	28480	HPA2900	102731	2
	CR24	Same as CR1				
	CR49	DIODE, Zener 9.1V	04713	1N4739A	100425	1
	CR50	DIODE, Zener 10V	04713	1N4740A	102873	1
	CR51 thru CR64	Same as CR1				
	CR80 thru CR88	Same as CR1				
	CR100	Same as CR1				
	CR101	Same as CR1				
	CR102	Same as CR1				
	CR120	Same as CR1				
	CR121	Same as CR1				

REPLACEABLE PARTS LIST

TITLE						
FRONT END PC ASSEMBLY #37000-914 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	CR140	Same as CR23				
	CR160	Same as CR1				
	CR161	Same as CR1				
	CR162	Same as CR1				
	CR163	Same as CR1				
	CR180	DIODE, Signal	26466	1N955	106548	3
	CR188	DIODE, Zener 4.7V	15818	1N750A	112135	2
	CR190	DIODE, Zener 15V	04713	1N4744A	100422	2
	CR191	Same as CR1				
	thru					
	CR202					
	CR210	Same as CR180				
	CR211	Same as CR180				
	CR230	Same as CR190				
	CR231	Same as CR1				
	thru					
	CR242					
	CR243	Same as CR188				
	CR250	Same as CR1				
	CR251	Same as CR1				
	CR252	Same as CR1				
	L20	INDUCTOR, Fixed 3.6 μ H	02114	VK200-20/4B	106673	1
	L21	INDUCTOR, .15 μ H 10%	99800	1025-00	106684	2
	L54	INDUCTOR, 0.1 μ H	99800	1025-94	106682	1
	L55	INDUCTOR, 0.22 μ H 10%	99800	1025-04	106680	2
	L56	INDUCTOR, 0.47 μ H	99800	1025-12	106686	4
	L119	Same as L56				
	L121	Same as L21				
	L140	INDUCTOR, 0.33 μ H 10%	99800	1025-08	106683	1
	L160	Same as L56				
	L161	INDUCTOR, 0.56 μ H	99800	1025-14	106688	1
	L181	Same as L55				
	L211	Same as L56				
	Q1	TRANSISTOR	52542	112148	112148	11
	Q2	TRANSISTOR, SINPN 30V	07263	PN3641-5	106586	7
	Q3	Same as Q2				
	Q4	Same as Q1				

REPLACEABLE PARTS LIST

TITLE						
FRONT END PC ASSEMBLY #37000-914 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	Q5	TRANSISTOR, SIPNP 25V	07263	MPS3638-5	101360	5
	Q6	TRANSISTOR	52542	112150	112150	13
	Q7	TRANSISTOR, SIPNP	04713	MPS-A65	101404	1
	Q8	Same as Q6				
	Q9	TRANSISTOR, SINPN 30V	56289	TD101	106614	1
	Q10	TRANSISTOR, SINPN 12V	02735	2N5179	101388	2
	Q11	Same as Q10				
	Q12	Same as Q1				
	Q13	Same as Q1				
	Q14	TRANSISTOR, SINPN 30V	56289	TZ-82	106610	1
	Q15	TRANSISTOR, SIPNP 50V	07263	2N5087	106575	11
	Q16	Same as Q15				
	Q17	Same as Q15				
	Q18	Same as Q2				
	Q19	Same as Q1				
	Q20	Same as Q5				
	Q21	Same as Q1				
	Q22	Same as Q1				
	Q24	Same as Q5				
	Q25	Same as Q6				
	Q26	Same as Q6				
	Q27	Same as Q1				
	Q28	Same as Q1				
	Q29	Same as Q6				
	Q30	Same as Q6				
	Q31	Same as Q6				
	Q32	Same as Q6				
	Q33	Same as Q1				
	Q34	Same as Q1				
	Q35	Same as Q6				
	Q36	Same as Q5				
	Q37	Same as Q2				
	Q38	TRANSISTOR, SIPNP 12V	07263	PN4258-18	102675	2
	Q39	Same as Q38				
	Q40 thru Q47	Same as Q15				

REPLACEABLE PARTS LIST

TITLE						
FRONT END PC ASSEMBLY #37000-914 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	Q48	Same as Q2				
	Q49	Same as Q6				
	Q50	Same as Q6				
	Q51	Same as Q6				
	Q52	Same as Q6				
	Q53	Same as Q2				
	Q54	Same as Q5				
	Q55	Same as Q2				
	R1	RESISTOR, CC 1.8 k 5%, 1/4W	01121	CB1825	101602	11
	R2	RESISTOR, CC 100 Ω 5%, 1/2W	01121	EB1015	101498	6
	R3	Same as R2				
	R4	Same as R1				
	R5	RESISTOR, CC 10 k 5%, 1/4W	01121	CB1035	101570	8
	R6	RESISTOR, CC 150 Ω 5%, 1/4W	01121	CB1515	101615	7
	R7	Same as R1				
	R8	RESISTOR, CC 18 k 5%, 1/4W	01121	CB1835	101579	3
	R9	RESISTOR, CC 2.2 k 5%, 1/4W	01121	CB2225	101562	1
	R10	RESISTOR, CC 2 k 5%, 1/4W	01121	CB2025	101553	2
	R11	RESISTOR, CC 680 Ω 5%, 1/4W	01121	CB6815	101669	1
	R12	RESISTOR, CC 62 Ω 5%, 1/4W	01121	CB6205	101736	2
	R13	RESISTOR, CC 10 Ω 5%, 1/4W	01121	CB1005	101557	2
	R19	RESISTOR, CC 130 k 5%, 1/4W	01121	CB1345	101603	1
	R20	RESISTOR, MF 4.53 k .5%, 1/2W	81349	RN70E	106345	2
	R21	RESISTOR, Variable 1 k 10%, 1/2W	01121	SV1021	106121	1
	R22	RESISTOR, MF 3.57 k 1%, 1/2W	81349	RN60C3571F	106183	2

REPLACEABLE PARTS LIST

TITLE						
FRONT END PC ASSEMBLY #37000-914 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R23	Same as R22				
	R24	RESISTOR, MF 2.43 k 1%, 1/8W	81349	RN60D	106229	3
	R25	RESISTOR, CC 15 k 5%, 1/4W	01121	CB1535	101552	3
	R26	RESISTOR, MF 845 Ω .5%, 1/2W	81349	RN70E8450D	106346	1
	R27	RESISTOR, CC 1 k 5%, 1/4W	01121	CB1025	101569	7
	R28	RESISTOR, MF 931 Ω .5%, 1/2W	81349	RN70E9310D	106347	1
	R29	RESISTOR, CC 270 Ω 5%, 1/4W	01121	CB2715	101542	6
	R30	Same as R20				
	R31	RESISTOR, CC 330 Ω 5%, 1/4W	01121	CB3315	101536	2
	R32	RESISTOR, Variable 500 Ω 10%, 1/2W	01121	SV5011	106131	10
	R33	RESISTOR, MF 2.26 k 1%, 1/8W	81349	RN60C2261F	106174	2
	R34	Same as R33				
	R35	RESISTOR, CC 82 Ω 5%, 1/4W	01121	CB8205	101629	2
	R36	RESISTOR, CC 22 Ω 5%, 1/4W	01121	CB2205	101696	1
	R37	Same as R6				
	R38	RESISTOR, CC 1.8 k 5%, 1/2W	01121	EB1825	101466	1
	R39	Same as R6				
	R40	Same as R29				
	R41	RESISTOR, CC 6.8 k 5%, 1/4W	01121	CB6825	101544	1
	R42	Same as R1				
	R43	Same as R5				
	R50	RESISTOR, CC 620 Ω 5%, 1/4W	01121	CB6215	101688	13
	R51	Same as R50				
	R52	Same as R50				
	R53	RESISTOR, CC 5.1 k 5%, 1/4W	01121	CB5125	101541	3

REPLACEABLE PARTS LIST

TITLE FRONT END PC ASSEMBLY #37000-914 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R54	Same as R53				
	R55	Same as R53				
	R56	RESISTOR, CC 390 Ω 5%, 1/4W	01121	CB3915	101592	9
	R57	Same as R56				
	R58	Same as R56				
	R59	RESISTOR, CC 750 Ω 5%, 1W	01121	GB7515	101857	7
	R60	Same as R32				
	R61	Same as R59				
	R62	Same as R32				
	R63	Same as R59				
	R64	Same as R32				
	R65	Same as R59				
	R66	Same as R32				
	R67	Same as R59				
	R68	Same as R32				
	R69	Same as R59				
	R70	Same as R32				
	R71	Same as R59				
	R72	Same as R32				
	R73	RESISTOR, CC 22 k 5%, 1/8W	01121	BB2235	101797	3
	R74	Same as R73				
	R75	Same as R73				
	R76 1	Same as R13				
	R80	Same as R1				
	R81	Same as R1				
	R82	Same as R2				
	R83	Same as R2				
	R84	Same as R5				
	R85	Same as R1				
	R86	Same as R29				
	R87	Same as R50				
	R88	RESISTOR, CC 1.2 k 5%, 1/4W	01121	CB1235	101565	2

REPLACEABLE PARTS LIST

TITLE FRONT END PC ASSEMBLY #37000-914 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R89	RESISTOR, CC 200 Ω 5%, 1/4W	01121	CB2015	101555	8
	R90	RESISTOR, CC 3.3 k 5%, 1/4W	01121	CB3325	101559	3
	R91	RESISTOR, CC 560 Ω 5%, 1/4W	01121	CB5615	101583	1
	R92	Same as R27				
	R93	Same as R89				
	R94	Same as R90				
	R95	Same as R27				
	R96	RESISTOR, CC 3 k 5%, 1/4W	01121	CB3025	101548	4
	R97	RESISTOR, CC 20 k 5%, 1/4W	01121	CB2035	101607	1
	R98	Same as R90				
	R100	Same as R2				
	R101	RESISTOR, CC 220 Ω 5%, 1/4W	01121	CB2215	101566	1
	R102	Same as R88				
	R103	Same as R31				
	R104	Same as R11				
	R106	RESISTOR, CC 820 Ω 5%, 1/4W	01121	CB8215	101567	4
	R107	Same as R29				
	R108	Same as R5				
	R110	Same as R50				
	R111	Same as R1				
	R112	Same as R2				
	R113	RESISTOR, CC 100 Ω 5%, 1/4W	01121	CB1015	101609	3
	R114	Same as R96				
	R115	RESISTOR, CC 130 Ω 5%, 1/4W	01121	CB1315	101627	1
	R120	RESISTOR, CC 2.7 k 5%, 1/4W	01121	CB2725	101599	2
	R121	Same as R35				
	R122	RESISTOR, CC 2.4 k 5%, 1/2W	01121	EB2425	101545	1

REPLACEABLE PARTS LIST

TITLE						
FRONT END PC ASSEMBLY #37000-914 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R123	RESISTOR, CC 180 Ω 5%, 1/4W	01121	CB1815	101668	3
	R124	RESISTOR, CC 51 Ω 5%, 1/4W	01121	CB5105	101672	3
	R125	Same as R27				
	R126	Same as R6				
	R127	RESISTOR, CC 1.5 k 5%, 1/2W	01121	EB1525	101459	3
	R128	RESISTOR, CC 47 Ω 5%, 1/4W	01121	CB4705	101560	1
	R129	RESISTOR, CC 27 Ω 5%, 1/4W	01121	CB2705	101729	1
	R130	Same as R106				
	R140	Same as R113				
	R141	Same as R27				
	R142	Same as R113				
	R143	Same as R106				
	R144	Same as R106				
	R145	Same as R89				
	R146	RESISTOR, CC 1.5 k 5%, 1W	01121	GB1525	101841	1
	R147	Same as R27				
	R148	RESISTOR, CC 430 Ω 5%, 1/4W	01121	CB4315	101774	1
	R149	Same as R6				
	R150	RESISTOR, CC 1.2 k 5%, 1W	01121	GB1225	101506	3
	R151	Same as R8				
	R152	Same as R12				
	R153	Same as R50				
	R154	Same as R89				
	R160	RESISTOR, CC 120 Ω 5%, 1/4W	01121	CB1215	101717	1
	R161	RESISTOR, CC 6.2 k 5%, 1/4W	01121	CB6225	101608	1
	R162	Same as R50				
	R163	Same as R1				
	R164	RESISTOR, CC 750 Ω 5%, 2W	01121	HB7515	106053	1

REPLACEABLE PARTS LIST

TITLE						
FRONT END PC ASSEMBLY #37000-914 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R165	RESISTOR, CC 240 Ω 5%, 1/4W	01121	CB2415	101588	2
	R166	Same as R165				
	R167	Same as R5				
	R168	Same as R1				
	R170	Same as R1				
	R171	Same as R27				
	R180	Same as R124				
	R181	Same as R123				
	R182	Same as R25				
	R183	Same as R150				
	R184	Same as R32				
	R185	Same as R89				
	R186	Same as R124				
	R187	Same as R24				
	R188	Same as R96				
	R189	Same as R29				
	R190	Same as R50				
	R191	Same as R50				
	R192	Same as R50				
	R193	RESISTOR, CC 3.9 k 5%, 1/4W	01121	CB3935	101561	6
	R194	Same as R193				
	R195	Same as R193				
	R196	Same as R56				
	R197	Same as R56				
	R198	Same as R56				
	R199	RESISTOR, SNO FM 1.2 k 5%, 1/2W	16299	C20	106278	12
	R200	Same as R199				
	R201	Same as R199				
	R202	Same as R199				
	R203	Same as R199				
	R204	Same as R199				
	R205	Same as R25				
	R209	RESISTOR, CC 150 Ω 5%, 1/8W	01121	BB1515	101702	1

REPLACEABLE PARTS LIST

TITLE						
FRONT END PC ASSEMBLY #37000-914 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R210	Same as R120				
	R211	Same as R6				
	R212	Same as R123				
	R213	Same as R209				
	R214	Same as R150				
	R215	Same as R32				
	R216	Same as R89				
	R217	Same as R6				
	R218	Same as R24				
	R219	Same as R96				
	R220	Same as R29				
	R230	Same as R50				
	R231	Same as R50				
	R232	Same as R50				
	R233	Same as R193				
	R234	Same as R193				
	R235	Same as R193				
	R236	Same as R56				
	R237	Same as R56				
	R238	Same as R56				
	R239	Same as R199				
	R240	Same as R199				
	R241	Same as R199				
	R242	Same as R199				
	R243	Same as R199				
	R244	Same as R199				
	R250	Same as R127				
	R251	Same as R89				
	R252	Same as R5				
	R253	Same as R5				
	R254	Same as R89				
	R255	Same as R127				
	R256	Same as R5				
	R257	RESISTOR, CC 1.5 k 5%, 1/4W	01121	CB1525	101577	1
	R258	RESISTOR, CC 1.2 k 5%, 1/4W	01121	CB1225	101581	1

REPLACEABLE PARTS LIST

TITLE						
FRONT END PC ASSEMBLY #37000-914 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	R259	Same as R8				
	R260	RESISTOR, CC 430 Ω 5%, 1W	01121	GB4315	101917	1
	R261	Same as R10				
	Z1	INTEGRATED CIRCUIT, TTL MSI BCD-To-Decimal Decoder/Driver	01295	SN7445N	106634	3
	Z2	INTEGRATED CIRCUIT, ECL 3 2-Input Line Receiver	04713	MC1035L	106657	1
	Z3	INTEGRATED CIRCUIT, MSC Linear Transistor Array	02735	CA3046	025725	2
	Z4	Same as Z1				
	Z5	Same as Z3				
	Z6	Same as Z1				

REPLACEABLE PARTS LIST

TITLE						
IEEE INTERFACE PC ASSEMBLY MODEL 154-4 ONLY #06710001						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	C1	CAPACITOR, Tant 22 μ F 10V	56289	196D226X9010A1	103496	2
	C2	Same as C1				
	C3	CAPACITOR, Ceramic .001 μ F 20%, 50V	71590	CW15C102M	100251	7
	C4	Same as C3				
	C5	Same as C3				
	C6	Same as C3				
	C7	Same as C3				
	C8	Same as C3				
	C9	Same as C3				
	C10	CAPACITOR, Ceramic .1 μ F +80-20%, 10V	71590	UK10-104	100120	2
	C11	Same as C10				
	C12	CAPACITOR, DM 1000 pF 5%, 100V	72136	DM15FA102JO	10024301	2
	C13	Same as C12				
	CR1	DIODE, Signal 50V	03508	1N4151	100385	2
	CR2	Same as CR1				
	R1	RESISTOR, CC 12 k 5%, 1/4W	01121	CB1235	101565	1
	R2	RESISTOR, CC 22 k 5%, 1/4W	01121	CB2235	101572	2
	R3	Same as R2				
	R4	RESISTOR, CC 1 k 5%, 1/4W	01121	CB1025	101569	1
	R5	RESISTOR, CC 1M 5%, 1/4W	01121	CB1055	101605	2
	R6	Same as R5				
	R7	RESISTOR, CC 1.8 k 5%, 1/4W	01121	CB1825	101602	2
	R8	Same as R7				
	U1	INTEGRATED CIRCUIT Resistor Network 4 x 12 k	52542	045008	045008	1
	U2	INTEGRATED CIRCUIT Resistor Network 4 x 6.2 k	52542	067116	067116	4
	U3	Same as U2				
	U4	Same as U2				
	U5	Same as U2				

REPLACEABLE PARTS LIST

TITLE						
IEEE INTERFACE PC ASSEMBLY MODEL 154-4 ONLY #06710001 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	U6	INTEGRATED CIRCUIT Resistor Network 4 x 3 k	52542	067115	067115	4
	U7	Same as U6				
	U8	Same as U6				
	U9	Same as U6				
	U10	INTEGRATED CIRCUIT, TTL Quad Latch	01295	SN7475N	019710	2
	U11	Same as U10				
	U12	INTEGRATED CIRCUIT, TTL 4 - 16 Line Decoder	01295	SN74154N	106640	1
	U13	INTEGRATED CIRCUIT, TTL Quad 2-Input NAND Gate	01295	SN7400N	019705	2
	U14	INTEGRATED CIRCUIT, TTL SSI Quad 2-Input AND Gate	01295	SN7408N	103093	2
	U15	INTEGRATED CIRCUIT, TTL Dual 4-Input AND Gate	01295	SN74LS21N	103970	1
	U16	INTEGRATED CIRCUIT, TTL SSI Hex Inverter	01295	SN7404N	025779	1
	U17	INTEGRATED CIRCUIT, TTL 8-Input NAND Gate	01295	SN7430N	025726	1
	U18	INTEGRATED CIRCUIT, TTL 5-Bit Comparator	07263	93L24PC	117020	1
	U19	INTEGRATED CIRCUIT, TTL Hex Inverter	01295	SN7414N	117078	2
	U20	Same as U19				
	U21	INTEGRATED CIRCUIT, TTL Hex Inverter	01295	SN7416N	045230	4
	U22	Same as U21				
	U23	Same as U21				
	U24	Same as U21				
	U25	INTEGRATED CIRCUIT, TTL Dual J-K Flip-Flop	01295	SN74S112N	025786	1
	U26	Same as U14				
	U27	INTEGRATED CIRCUIT, TTL Triple 3-Input NAND Gate	01295	SN7410N	019706	1
	U28	INTEGRATED CIRCUIT, TTL SSI Quad 2-Input OR Gate	01295	SN7432N	045257	1
	U29	Same as U13				

REPLACEABLE PARTS LIST

TITLE						
IEEE INTERFACE PC ASSEMBLY MODEL 154-4 ONLY #06710001 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	U30	INTEGRATED CIRCUIT, TTL Hex Buffer	01295	SN7417N	106629	1
	U31	INTEGRATED CIRCUIT, TTL Dual D Flip-Flop	01295	SN7474N	025241	1
	U32	INTEGRATED CIRCUIT, TTL Dual One-Shot MVB	01295	SN74123N	045209	1
	U33	INTEGRATED CIRCUIT Resistor Network 4 x 1.8 k	52542	067114	067114	5
	U34	Same as U33				
	U35	Same as U33				
	U36	Same as U33				
	U37	Same as U33				

REPLACEABLE PARTS LIST

TITLE						
VUL/VLL CONTROL PCB ASSEMBLY #37001437						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	C1	CAPACITOR, Ceramic .022 μ F 20%, 25V	71590	2DDU60E223M	106483	1
	C2	CAPACITOR, Ceramic .01 μ F +80-20%, 100V	91418	TA110	100103	4
	C21	Same as C2				
	C41	CAPACITOR, Tant 22 μ F 20%, 20V	31433	T362C226M025AS	112281	1
	C91	Same as C2				
	C92	CAPACITOR, Tant 6.8 μ F 20%, 35V	56289	196D685X0035E1	106515	4
	C93	Same as C92				
	C94	Same as C92				
	C111	Same as C2				
	C112	Same as C92				
	CR1	DIODE, Silicon	07163	1N4150/1N3600	112127	19
	CR2	Same as CR1				
	CR3	DIODE, Zener 9.1V	04713	1N960B	100430	18
	CR4	Same as CR3				
	CR5	Same as CR3				
	CR22	Same as CR3				
	CR41	Same as CR1				
	CR42	Same as CR1				
	CR71	Same as CR1				
	CR72	Same as CR1				
	CR73	Same as CR1				
	CR81	Same as CR1				
	CR82	Same as CR1				
	CR83	Same as CR1				
	CR91	Same as CR3				
	CR92	Same as CR3				
	CR93	Same as CR1				
	CR94	Same as CR1				
	CR95	Same as CR1				
	CR96	Same as CR1				
	CR97	Same as CR1				
	CR98	Same as CR1				
	CR99	DIODE, Zener 8.2V	04713	1N959B	100429	1

REPLACEABLE PARTS LIST

TITLE						
VUL/VLL CONTROL PCB ASSEMBLY #37001437 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	CR100	Same as CR1				
	CR101	Same as CR1				
	CR111	Same as CR3				
	CR112	Same as CR3				
	CR113	Same as CR3				
	Q1	TRANSISTOR, SIPNP	07263	2N5087	106575	3
	Q21	Same as Q1				
	Q41	TRANSISTOR, SINPN	56289	TZ-82	106610	8
	Q42	Same as Q41				
	Q43	Same as Q41				
	Q44	Same as Q41				
	Q45	Same as Q41				
	Q46	Same as Q41				
	Q47	Same as Q41				
	Q48	Same as Q41				
	Q71	TRANSISTOR, SINPN 30V	07263	PN3641-5	106586	3
	Q72	TRANSISTOR, SIPNP 25V	04713	MPS3638-5	101360	2
	Q81	Same as Q71				
	Q82	Same as Q72				
	Q91	Same as Q1				
	Q92	TRANSISTOR, SIPNP	04713	2N4918	101387	1
	Q111	Same as Q71				
	R1	RESISTOR, CC 390 Ω 5%, 1/4W	01121	CB3915	101592	1
	R2	RESISTOR, Variable 100 k 10%, 1/2W	73138	89PR100K	106135	4
	R3	RESISTOR, MF 301 k 1%, 1/8W	81349	RN60C3013F	106180	2
	R4	RESISTOR, MF 2.43 k 1%, 1/8W	16299	NA60	106229	2
	R5	RESISTOR, MF 383 Ω .5%, 1/8W	81349	RN60C3830D	106342	2
	R6	RESISTOR, CC 100 Ω 5%, 1/4W	01121	CB1015	101609	4
	R7	RESISTOR, CC 1.8 k 5%, 1/4W	01121	CB1825	101602	6
	R8	Same as R7				

REPLACEABLE PARTS LIST

TITLE						
VUL/VLL CONTROL PCB ASSEMBLY #37001437 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	R9	RESISTOR, CC 10 k 5%, 1/4W	01121	CB1035	101570	7
	R10	Same as R7				
	R11	RESISTOR, CC 1.3 k 5%, 1/4W	01121	CB1325	101556	4
	R12	Same as R9				
	R14	Same as R11				
	R15	Same as R9				
	R21	Same as R2				
	R22	Same as R3				
	R23	Same as R4				
	R24	Same as R5				
	R25	Same as R7				
	R26	Same as R11				
	R27	Same as R9				
	R28	Same as R7				
	R29	Same as R11				
	R31	Same as R6				
	R41	RESISTOR, MF 90 k 1%, 1/8W	81349	RN60D9531F	106327	2
	R42	RESISTOR, MF 10 k 1%, 1/8W	81349	RN60C1002F	106162	2
	R43	RESISTOR, MF 7.15 k 1%, 1/8W	81349	RN60C7151F	106198	2
	R44	RESISTOR, MF 71.5 k 1%, 1/8W	81349	RN60C7152F	106199	2
	R45	RESISTOR, MF 10.2 k 1%, 1/8W	81349	RN60C1022F	106206	1
	R46	RESISTOR, CC 820 k 5%, 1/4W	01121	CB8245	101850	1
	R47	RESISTOR, CC 15 k 5%, 1/4W	01121	CB1535	101552	4
	R48	RESISTOR, CC 12 k 5%, 1/4W	01121	CB1235	101565	4
	R49	Same as R47				
	R50	Same as R48				
	R51	Same as R48				
	R52	Same as R47				
	R53	Same as R48				

REPLACEABLE PARTS LIST

TITLE						
VUL/VLL CONTROL PCB ASSEMBLY #37001437 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	R54	Same as R47				
	R55	Same as R44				
	R56	Same as R43				
	R57	RESISTOR, MF 47.5 k 1%, 1/4W	81349	RN60D1072F	106311	1
	R58	Same as R41				
	R59	Same as R42				
	R71	Same as R9				
	R72	RESISTOR, CC 390 k 5%, 1/4W	01121	CB3945	101787	2
	R73	RESISTOR, MF 47.5 k 1%, 1/8W	81349	RN60C4752F	106189	2
	R74	RESISTOR, Variable 10 k 10%, 3/8W	73138	89PR10K	102472	4
	R75	RESISTOR, MF 51.1 k 1%, 1/8W	81349	RN60C5112F	106192	2
	R76	RESISTOR, MF 1 MΩ 1%, 1/8W	81349	RN60C1004F	106163	2
	R81	Same as R9				
	R82	Same as R72				
	R83	Same as R73				
	R84	Same as R74				
	R85	Same as R75				
	R86	Same as R76				
	R91	RESISTOR, Film 4.99 MΩ 1%, 1/4W	91637	DC-1/4	106158	2
	R92	Same as R2				
	R93	RESISTOR, MF 20 k 1%, 1/8W	81349	RN60D2002F	106315	2
	R94	Same as R74				
	R95	Same as R6				
	R96	RESISTOR, CC 20 k 5%, 1/4W	01121	CB2035	101607	2
	R97	RESISTOR, MF 2 k .5%, 1/2W	16299	C20	106280	2
	R111	Same as R91				
	R112	Same as R2				
	R113	Same as R93				
	R114	Same as R74				

REPLACEABLE PARTS LIST

TITLE						
VUL/VLL CONTROL PCB ASSEMBLY #37001437 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R115	Same as R6				
	R117	Same as R97				
	R118	Same as R96				
	Z1	INTEGRATED CIRCUIT Operational Amplifier	07263	μ A741	106621	4
	Z21	Same as Z1				
	Z41	INTEGRATED CIRCUIT 2-4 Channel Dist	04713	MC9807	106645	1
	Z91	Same as Z1				
	Z111	Same as Z1				

REPLACEABLE PARTS LIST

TITLE						
VARIABLE RISE/FALL POWER SUPPLY MODEL 154 ONLY #37001-429						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	C1	CAPACITOR, Ceramic .001 μ F +80-20%, 100V	91418	TA110	100103	9
	C2	Same as C1				
	C20	Same as C1				
	C40	Same as C1				
	C60	Same as C1				
	C61	Same as C1				
	C62	CAPACITOR, DM 100 pF 5%, 500V	72136	DM15FD101JO	100173	2
	C63	CAPACITOR, DM 33 pF 5%, 500V	72136	DM15ED330JO	100175	2
	C64	CAPACITOR, Ceramic .022 μ F 25%, 25V	71590	2DDU60E223M	106483	2
	C65	CAPACITOR, Tant 6.8 μ F 20%, 35V	56289	196D865X0035E1	106515	4
	C80	CAPACITOR, Tant 22 μ F 20%, 20V	31433	T362C226M025AS	112281	2
	C81	Same as C1				
	C90	Same as C1				
	C91	Same as C1				
	C92	Same as C80				
	C93	Same as C62				
	C94	Same as C63				
	C95	Same as C64				
	C96	Same as C65				
	C110	CAPACITOR, Tant 1 μ F 20%, 35V	56289	164D105X0035A2	106522	2
	C111	Same as C65				
	C112	Same as C110				
	C113	Same as C65				
	CR80	DIODE, Zener 5.1V	03877	1N751A	100378	1
	CR110	DIODE, Zener 9.1V	04713	1N4739A	100425	2
	CR111	Same as CR110				
	Q60	TRANSISTOR, SINPN	07263	2N2219A	106587	2
	Q61	TRANSISTOR, SIPNP 30V	56289	TD401	106615	1
	Q62	TRANSISTOR, Selected	52542	112154	112154	2
	Q63	TRANSISTOR, SINPN 30V	07263	PN3641-5	106586	1

REPLACEABLE PARTS LIST

TITLE						
VARIABLE RISE/FALL POWER SUPPLY MODEL 154 ONLY #37001-429 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	Q64	TRANSISTOR, SIPNP	07263	2N5087	106575	1
	Q65	TRANSISTOR, SIPNP	04713	2N2904A	106572	1
	Q66	TRANSISTOR, SIPNP	04713	MPS U52	106577	1
	Q80	Same as Q62				
	Q91	TRANSISTOR, SIPNP 30V	04713	MPS A65	101404	1
	Q92	TRANSISTOR, SINPN	07263	MPS3638-5	101360	1
	Q93	TRANSISTOR, SINPN	56289	TZ-82	106610	1
	Q94	Same as Q60				
	Q95	TRANSISTOR, SINPN	04713	MSU-02	106594	1
	R1	RESISTOR, MF 10 k 1%, 1/8W	81349	RN60C1002F	106162	12
	R2	Same as R1				
	R3	Same as R1				
	R4	Same as R1				
	R5	RESISTOR, Variable 25 k 10%, 1/2W	73138	89PR25K	106136	2
	R6	RESISTOR, MF 100 k 1%, 1/8W	81349	RN60E1003F3	101967	1
	R7	RESISTOR, Variable 5 k 10%, 3/8W	73138	89PR5K	102473	3
	R8	RESISTOR, MF 8.25 k 1%, 1/8W	81349	RN60C8251F	106203	1
	R9	Same as R1				
	R20	Same as R1				
	R21	RESISTOR, MF 1 k 1%, 1/8W	81349	RN60C1001F	106161	3
	R22	RESISTOR, MF 4.99 k 1%, 1/4W	91637	MFF 1/8 T1	102079	4
	R23	RESISTOR, Variable 10 k 10%, 3/8W	73138	89PR10K	102472	2
	R24	Same as R22				
	R25	RESISTOR, Variable 500 Ω 10%, 3/8W	73138	89PR500	102183	4
	R26	Same as R1				
	R40	Same as R1				
	R41	Same as R21				
	R42	Same as R23				
	R43	Same as R22				

REPLACEABLE PARTS LIST

TITLE						
VARIABLE RISE/FALL POWER SUPPLY MODEL 154 ONLY #37001-429 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R44	Same as R1				
	R45	Same as R25				
	R46	Same as R22				
	R60	RESISTOR, MF 681 Ω 1%, 1/4W	16299	NA60	106256	1
	R61	RESISTOR, CC 36 Ω 5%, 1/4W	01121	CB3605	101732	2
	R62	RESISTOR, CC 2.2 k 5%, 1/2W	01121	EB2225	101454	3
	R63	RESISTOR, CC 24 Ω 5%, 1/4W	01121	CB2405	101728	1
	R64	RESISTOR, MF 20 k 1%, 1/8W	81349	RN60C2002F	106172	1
	R65	Same as R25				
	R66	RESISTOR, Variable 100 k 10%, 1/2W	73138	89PR100K	106135	1
	R67	RESISTOR, MF 3.01 k 1%, 1/8W	81349	RN60D3012F	106318	4
	R68	RESISTOR, CC 10 k 5%, 1/4W	01121	CB1035	101570	1
	R69	Same as R1				
	R70	Same as R7				
	R71	Same as R67				
	R72	RESISTOR, CC 24 Ω 5%, 1W	01121	GB2405	106026	2
	R73	RESISTOR, CC 51 Ω 5%, 1W	01121	GB5105	106032	2
	R80	RESISTOR, CC 15 k 5%, 1/4W	01121	CB1535	101552	1
	R81	RESISTOR, CC 2.2 k 5%, 1/4W	01121	CB2225	101562	1
	R82	Same as R62				
	R90	Same as R5				
	R91	Same as R1				
	R92	RESISTOR, MF 511 k 1%, 1/8W	81349	RN60C5113F	106193	1
	R93	Same as R21				
	R94	Same as R62				
	R95	Same as R61				

REPLACEABLE PARTS LIST

TITLE						
VARIABLE RISE/FALL POWER SUPPLY MODEL 154 ONLY #37001-429 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R96	Same as R25				
	R97	Same as R67				
	R98	Same as R1				
	R99	Same as R67				
	R100	Same as R7				
	R101	Same as R72				
	R102	Same as R73				
	Z1	INTEGRATED CIRCUIT Operational Amplifier	07263	μ A741TC	106621	7
	Z2	Same as Z1				
	Z20	Same as Z1				
	Z40	Same as Z1				
	Z60	Same as Z1				
	Z61	INTEGRATED CIRCUIT Operational Amplifier	04713	LM308N	106627	2
	Z80	Same as Z1				
	Z81	Same as Z1				
	Z91	Same as Z61				

REPLACEABLE PARTS LIST

TITLE VARIABLE RISE/FALL OUTPUT AMPLIFIER PC ASSEMBLY MODEL 154 ONLY #37000-954						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	C1	CAPACITOR, Tant 22 μ F 20%, 35V	56289	150D116X0035R2	106527	2
	C2	Same as C1				
	C3	CAPACITOR, Ceramic .47 μ F +80-20%, 10V	71590	UK10474	106482	3
	C4	CAPACITOR, DM 39 pF 5%, 500V	72136	DM15ED390JO	102547	1
	C5	CAPACITOR, DM 68 pF 5%, 500V	72136	DM10ED680JO	100329	1
	C6	Same as C3				
	C8	CAPACITOR, DM 680 pF 5%, 300V	72136	DM15FC681SO	100275	1
	C9	Same as C3				
	C11	CAPACITOR, Mylar .015 μ F 5%, 100V	27556	ZP2B153J	106417	1
	C31	CAPACITOR, Ceramic .022 μ F 25%, 25V	71590	2DDU60E223M	106483	15
	C32	Same as C31				
	C33	CAPACITOR, Ceramic .05 μ F 25V	72982	5855Y5U 503Z	106484	6
	C34	CAPACITOR, Ceramic .1 μ F 25V	71590	DDA104	106485	1
	C35	Same as C31				
	C59	CAPACITOR, DM 390 pF 5%, 500V	72136	DM15FD391JO	100170	2
	C60	Same as C59				
	C61	Same as C33				
	C62	CAPACITOR, Chip .01 μ F 20%, 50V	26654	17BX050S103M	106508	4
	C63	Same as C62				
	C64	Same as C33				
	C65	CAPACITOR, Tant 47 μ F 20%, 20V	56289	196D476X020LA1	106514	2
	C66	Same as C65				
	C67	CAPACITOR, Tant 33 μ F 20%, 25V	56289	196D336X0025LA3	106512	2
	C68	Same as C67				
	C69	Same as C31				
	C70	Same as C33				

REPLACEABLE PARTS LIST

TITLE . VARIABLE RISE/FALL OUTPUT AMPLIFIER PC ASSEMBLY MODEL 154 ONLY #37000-954 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	C71	Same as C62				
	C72	Same as C62				
	C73	Same as C33				
	C81	CAPACITOR, DM 220 pF 5%, 500V	72136	DM15FD221JO	100220	1
	C82	Same as C31				
	C83	CAPACITOR, DM 270 pF 5%, 500V	72136	DM15FD271JO	100238	1
	C84	Same as C31				
	C85	Same as C31				
	C86	Same as C31				
	C87	Same as C31				
	C88	Same as C31				
	C89	Same as C33				
	C97	CAPACITOR, DM 150 pF 5%, 500V	72136	DM15FD151JO	100219	1
	C98	CAPACITOR, DM 100 pF 5%, 500V	72136	DM15FD101JO	100173	1
	C101	Same as C31				
	C102	Same as C31				
	C103	CAPACITOR, DM 56 pF 5%, 500V	72136	DM15ED560JO	100179	1
	C104	Same as C31				
	C105	CAPACITOR, Tant 22 μ F 20%, 20V	31433	T362C226M025AS	112281	4
	C106	Same as C31				
	C107	Same as C105				
	C108	Same as C105				
	C109	Same as C105				
	C110	Same as C31				
	CR1	DIODE, Silicon	07263	1N4150/1N3600	112127	26
	CR2 thru CR14	Same as CR1				
	CR31	DIODE, Zener 24V	07263	1N4749A	112140	2
	CR32	Same as CR31				
	CR33	DIODE, Zener 5.1V	03877	1N751A	100378	3
	CR34	DIODE, Zener 10V	03877	1N4740A	102873	2

REPLACEABLE PARTS LIST

TITLE VARIABLE RISE/FALL OUTPUT AMPLIFIER PC ASSEMBLY MODEL 154 ONLY #37000-954 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	CR35	Same as CR34				
	CR59	Same as CR1				
	CR60	Same as CR1				
	CR61	DIODE, Zener 18V	04713	1N4746A	112138	2
	CR62	DIODE, Signal 35V	28480	5082-1002	106554	3
	CR63	Same as CR62				
	CR64	Same as CR62				
	CR65	Same as CR61				
	CR81	DIODE, Zener 5.1V	04713	1N5231B	106550	2
	CR82	Same as CR33				
	CR83	Same as CR1				
	CR84	Same as CR1				
	CR85	Same as CR1				
	CR87	DIODE, Zener 3.3V	03877	1N746A	100415	4
	CR89	Same as CR87				
	CR90	Same as CR1				
	CR91	Same as CR				
	CR92	Same as CR1				
	CR93	Same as CR33				
	CR94	Same as CR81				
	CR101	Same as CR1				
	CR102	Same as CR1				
	CR103	Same as CR87				
	CR104	Same as CR87				
	CR105	Same as CR1				
	CR106	Same as CR1				
	J1	CONNECTOR, PC Mt.	16733	1115-2	106735	3
	J2	Same as J1				
	J3	Same as J1				
	L61	INDUCTOR, Fixed 3.6 μ H	02114	VK200-20/4B	106673	1
	L62	INDUCTOR, Fixed 35 μ H	99848	1035-15-350	106689	1
	Q1	TRANSISTOR, SINPN 30V	07263	PN3641-5	106586	7
	Q2	Same as Q1				
	Q3	Same as Q1				
	Q4	Same as Q1				
	Q5	Same as Q1				

REPLACEABLE PARTS LIST

TITLE VARIABLE FISE/FALL OUTPUT AMPLIFIER PC ASSEMBLY MODEL 154 ONLY #37000-954 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	Q6	TRANSISTOR	52542	112150	112150	9
	Q7	Same as Q1				
	Q8	Same as Q6				
	Q9	Same as Q1				
	Q10	Same as Q6				
	Q11	TRANSISTOR	52542	112148	112148	4
	Q12	Same as Q11				
	Q13	TRANSISTOR	52542	112155	112155	7
	Q14	Same as Q13				
	Q15	Same as Q13				
	Q16	Same as Q13				
	Q17	TRANSISTOR, SIPNP	04713	2N4918	101387	2
	Q18	TRANSISTOR, SIPNP 30V	04713	2N5583	106579	4
	Q19	Same as Q18				
	Q20	Same as Q13				
	Q22	TRANSISTOR, SINPN	04713	2N4921	101386	1
	Q23	TRANSISTOR, SINPN	01295	2N2270	101346	1
	Q24	Same as Q11				
	Q25	Same as Q11				
	Q26	Same as Q18				
	Q27	TRANSISTOR, SINPN 20V	02735	2N5109	106591	1
	Q28	Same as Q6				
	Q29	Same as Q6				
	Q30	TRANSISTOR, SIPNP	04713	2N2904A	106572	1
	Q31	Same as Q6				
	Q32	Same as Q6				
	Q33	Same as Q17				
	Q34	Same as Q13				
	Q35	Same as Q18				
	Q36	Same as Q22				
	Q37	Same as Q6				
	Q38	Same as Q6				
	Q39	Same as Q13				
	R1	RESISTOR, CC 1.8 k 5%, 1/4W	01121	CB1825	101602	9
	R2	Same as R1				

REPLACEABLE PARTS LIST

TITLE VARIABLE RISE/FALL OUTPUT AMPLIFIER PC ASSEMBLY MODEL 154 ONLY #37000-954 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R3	RESISTOR, CC 10 k 5%, 1/4W	01121	CB1035	101570	3
	R4	Same as R1				
	R5	Same as R1				
	R6	Same as R1				
	R7	Same as R1				
	R8	Same as R3				
	R9	RESISTOR, CC 300 Ω 5%, 1/4W	01121	CB3015	101537	1
	R10	Same as R1				
	R11	RESISTOR, CC 1.5 k 5%, 1/4W	01121	CB1525	101577	1
	R12	Same as R3				
	R13	Same as R1				
	R14	RESISTOR, CC 470 Ω 5%, 1/4W	01121	CB4715	101625	3
	R15	RESISTOR, CC 18 Ω 5%, 1/2W	01121	EB1805	101863	3
	R16	RESISTOR, CC 2.2 k 5%, 1/4W	01121	CB2225	101562	3
	R17	RESISTOR, CC 39 Ω 5%, 1/8W	01121	BB3905	101813	1
	R18	Same as R14				
	R19	Same as R15				
	R20	Same as R16				
	R21	Same as R14				
	R22	Same as R15				
	R23	Same as R16				
	R31	RESISTOR, CC 51 Ω 5%, 1/4W	01121	CB5105	101672	16
	R32	Same as R31				
	R33	Same as R31				
	R34	RESISTOR, CC 5.1 k 5%, 1/4W	01121	CB5125	101541	2
	R35	RESISTOR, CC 10 Ω 5%, 1/4W	01121	CB1005	101557	2
	R36	RESISTOR, CC 750 Ω 5%, 1/2W	01121	EB7515	101496	1
	R37	Same as R35				

REPLACEABLE PARTS LIST

TITLE VARIABLE RISE/FASS OUTPUT AMPLIFIER PC ASSEMBLY MODEL 154 ONLY #37000-954 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	R38	Same as R31				
	R39	Same as R34				
	R40	Same as R31				
	R41	Same as R31				
	R42	Same as R31				
	R43	Same as R31				
	R44	RESISTOR, CC 6.8 k 5%, 1/4W	01121	CB6825	101544	2
	R45	Same as R44				
	R46	Same as R31				
	R47	Same as R31				
	R48	RESISTOR, CC 200 Ω 5%, 1/4W	01121	CB2015	105555	2
	R49	Same as R31				
	R50	Same as R31				
	R51	Same as R31				
	R52	Same as R31				
	R53	Same as R48				
	R54	RESISTOR, CC 1 k 5%, 1/4W	01121	CB1025	101569	6
	R62	RESISTOR, CC 390 Ω 5%, 1/4W	01121	CB3915	101592	4
	R63	RESISTOR, CC 33 Ω 5%, 1/4W	01121	CB3305	101731	4
	R64	Same as R63				
	R65	Same as R63				
	R66	Same as R63				
	R67	Same as R62				
	R68	Same as R61				
	R81	RESISTOR, CC 2 k 5%, 1W	01121	GB2025	101842	2
	R82	Same as R61				
	R83	RESISTOR, CC 240 Ω 5%, 1/2W	01121	EB2415	101493	2
	R84	Same as R62				
	R85	RESISTOR, CC 150 Ω 5%, 1/4W	01121	CB1515	101615	4
	R86	Same as R85				

REPLACEABLE PARTS LIST

TITLE VARIABLE RISE/FALL OUTPUT AMPLIFIER PC ASSEMBLY MODEL 154 ONLY #37000-954 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R87	RESISTOR, CC 110 Ω 5%, 1/4W	01121	CB1115	101664	2
	R88	Same as R31				
	R89	Same as R87				
	R90	Same as R62				
	R91	Same as R85				
	R92	Same as R85				
	R93	Same as R81				
	R94	Same as R83				
	R95	Same as R61				
	R101	RESISTOR, CC 100 Ω 5%, 1/4W	01121	CB1015	101609	2
	R102	RESISTOR, CC 12 Ω 5%, 2W	01121	HB1205	101879	2
	R103	RESISTOR, CC 2.2 Ω 5%, 1/2W	01121	EB22G5	106012	4
	R104	Same as R31				
	R105	Same as R103				
	R106	Same as R31				
	R107	Same as R103				
	R108	Same as R61				
	R109	Same as R61				
	R110	Same as R103				
	R111	Same as R101				
	R112	Same as R102				

REPLACEABLE PARTS LIST

TITLE CIRCUIT BOARD ASSEMBLY—FIXED RISE/FALL OUTPUT AMPLIFIER Model 153 Only #37000919						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	C425	CAPACITOR, Tant 22 μ F 20%, 25V	31433	T362C226M025AS	112281	9
	C426	CAPACITOR, Ceramic .022 μ F 25%, 25V	71590	2DDU60E223M	106483	20
	C427	Same as C426				
	C428	CAPACITOR, Ceramic 6.8 pF 1000V	56289	C030B102E6R8D	100167	1
	C429	Same as C426				
	C430	CAPACITOR, Tant 22 μ F 20%, 35V	56289	150D226X0035R2	106527	4
	C431	Same as C426				
	C432	Same as C425				
	C433	Same as C426				
	C434	Same as C425				
	C435	Same as C426				
	C436	Same as C430				
	C437	Same as C425				
	C438	Same as C426				
	C439	Same as C425				
	C440	Same as C426				
	C441	Same as C426				
	C442	Same as C426				
	C443	Same as C426				
	C444	CAPACITOR, DM 5 pF 10%, 500V	72136	DM15CD050DO	100218	1
	C445	Same as C426				
	C446	Same as C426				
	C447	Same as C430				
	C448	Same as C426				
	C449	CAPACITOR, DM 10 pF 5%, 500V	72136	DM15CD100JO	100253	1
	C450	Same as C426				
	C451	Same as C425				
	C452	Same as C426				
	C453	Same as C426				
	C454	Same as C425				
	C455	Same as C425				

REPLACEABLE PARTS LIST

TITLE						
CIRCUIT BOARD ASSEMBLY—FIXED RISE/FALL OUTPUT AMPLIFIER #37000919 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	C456	Same as C430				
	C458	Same as C426				
	C460	Same as C426				
	C461	Same as C426				
	CR425	DIODE, Zener 13V	04713	1N964B	100412	1
	CR426	DIODE, Silicon	07263	1N4150/1N3600	112127	18
	CR427	Same as CR426				
	CR431	Same as CR426				
	CR432	Same as CR426				
	CR433	DIODE, Signal 35V	28480	5082-1022	106554	2
	CR434	Same as CR426				
	CR435	Same as CR426				
	CR436	Same as CR426				
	CR437	DIODE, Zener 5.1V	03877	1N751A	100378	2
	CR438	Same as CR433				
	CR439	Same as CR426				
	CR440	Same as CR437				
	CR441	DIODE, Zener 4.3V	04713	1N749A	100419	2
	CR442	Same as CR426				
	CR443	Same as CR426				
	CR444	Same as CR441				
	CR445	Same as CR426				
	CR446	Same as CR426				
	CR447	Same as CR426				
	CR448	Same as CR426				
	CR449	DIODE, Zener 5.1V	04713	1N5231B	106550	2
	CR450	DIODE, Zener 3.3V	03877	1N746A	100415	2
	CR451	Same as CR426				
	CR452	Same as CR426				
	CR454	Same as CR449				
	CR455	Same as CR450				
	CR456	Same as CR426				
	CR457	Same as CR426				
	J425	CONNECTOR, BNC	16733	1115-2	106735	3
	J426	Same as J425				
	J427	Same as J425				

REPLACEABLE PARTS LIST

TITLE						
CIRCUIT BOARD ASSEMBLY--FIXED RISE/FALL OUTPUT AMPLIFIER #37000919 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	L425	INDUCTOR, .12 μ H 10%	99800	1025-96	106685	1
	L426	INDUCTOR, .33 μ H 10%	99800	1025-08	106683	1
	Q425	TRANSISTOR, SINPN 30V	07263	PN3641-5	106586	1
	Q426	TRANSISTOR, SIPNP 12V	07263	PN4258-18	102675	4
	Q427	Same as Q426				
	Q428	TRANSISTOR, SIPNP 25V	07263	MPS3638-5	101360	1
	Q429	Same as Q426				
	Q430	Same as Q426				
	Q431	TRANSISTOR, SINPN 20V	02735	2N5109	106591	2
	Q432	TRANSISTOR, SINPN	56289	TZ-82	106610	1
	Q433	TRANSISTOR, SINPN	01295	2N2270	101346	2
	Q434	Same as Q431				
	Q435	TRANSISTOR, SINPN	04713	2N4921	101386	2
	Q436	TRANSISTOR	52542	112148	112148	4
	Q437	TRANSISTOR	52542	112150	112150	4
	Q438	Same as Q436				
	Q439	Same as Q437				
	Q440	TRANSISTOR, SIPNP	04713	2N2904A	106572	1
	Q441	Same as Q436				
	Q442	Same as Q437				
	Q443	Same as Q436				
	Q444	Same as Q437				
	Q445	Same as Q433				
	Q446	TRANSISTOR	52542	112155	112155	1
	Q447	TRANSISTOR, SIPNP 30V	04713	2N5583	106579	1
	Q448	Same as Q435				
	Q449	TRANSISTOR, SIPNP	04713	2N4918	101387	1
	R423	RESISTOR, CC 150 Ω 5%, 1/4W	01121	CB1515	101615	4
	R424	Same as R423				
	R425	RESISTOR, CC 820 Ω 5%, 1/2W	01121	EB8215	101656	2
	R426	RESISTOR, CC 51 Ω 5%, 1/4W	01121	CB5105	101672	4
	R427	Same as R426				
	R428	RESISTOR, CC 33 Ω 5%, 1/4W	01121	CB3305	101731	4

REPLACEABLE PARTS LIST

TITLE CIRCUIT BOARD ASSEMBLY – FIXED RISE/FALL OUTPUT AMPLIFIER #37000919 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R429	Same as R428				
	R430	Same as R425				
	R431	RESISTOR, CC 10 k 5%, 1/4W	01121	CB1035	101570	2
	R432	RESISTOR, CC 120 Ω 5%, 1/4W	01121	CB1215	101717	2
	R433	RESISTOR, CC 680 Ω 5%, 1/2Q	01121	EB6815	101475	1
	R434	Same as R431				
	R435	Same as R432				
	R436	RESISTOR, CC 2.2 k 5%, 1/4W	01121	CB2225	101562	2
	R437	Same as R436				
	R438	RESISTOR, CC 4.7 k 5%, 1/4W	01121	CB4725	101598	1
	R439	RESISTOR, CC 220 Ω 5%, 1/4W	01121	CB2215	101566	1
	R440	Same as R428				
	R441	Same as R428				
	R442	RESISTOR, CC 68 Ω 5%, 1/4W	01121	CB6805	101690	1
	R443	RESISTOR, CC 24 Ω 5%, 1W	01121	GB2405	106026	2
	R444	RESISTOR, CC 51 Ω 5%, 1W	01121	GB5105	106032	2
	R445	Same as R444				
	R446	Same as R443				
	R447	RESISTOR, CC 2 k 5%, 1W	01121	GB2025	101842	2
	R448	Same as R447				
	R449	RESISTOR, CC 300 Ω 5%, 1/4W	01121	CB3015	101537	4
	R450	Same as R449				
	R451	Same as R449				
	R452	Same as R449				
	R453	RESISTOR, CC 390 Ω 5%, 1/4W	01121	CB3915	101592	2
	R454	Same as R453				
	R455	RESISTOR, CC 240 Ω 5%, 1/2W	01121	EB2415	101493	2

REPLACEABLE PARTS LIST

TITLE						
CIRCUIT BOARD ASSEMBLY—FIXED RISE/FALL OUTPUT AMPLIFIER #37000919 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	R456	RESISTOR, CC 1 k 5%, 1/4W	01121	CB1025	101569	2
	R457	Same as R423				
	R458	Same as R423				
	R459	Same as R426				
	R460	Same as R426				
	R461	Same as R456				
	R462	Same as R455				
	R463	RESISTOR, CC 2.2 Ω 5%, 1/4W	01121	EB22G5	106012	4
	R464	Same as R463				
	R465	Same as R463				
	R466	Same as R463				
	R467	RESISTOR, CC 12 Ω 5%, 2W	01121	HB1205	101879	2
	R468	RESISTOR, CC 100 Ω 5%, 1/4W	01121	CB1015	101609	2
	R469	Same as R467				
	R470	RESISTOR, CC 510 Ω 5%, 1/2W	01121	EB5115	101767	1
	R471	Same as R468				

REPLACEABLE PARTS LIST

TITLE 150 POWER SUPPLIES AND REGULATORS PC ASSEMBLY #37000913						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	C501	CAPACITOR, El Can 15000 μ F, 50V	99392	23C50TS152	106468	2
	C502	CAPACITOR, Ceramic .1 μ F, 75V	71590	DDA104	106485	4
	C503	CAPACITOR, El Can 100 μ F, 35V	29309	20-500BP100	106460	3
	C504	CAPACITOR, Tant 4.7 μ F, 20V	56289	196D475X0035JA1	106513	1
	C521	Same as C501				
	C522	Same as C502				
	C523	Same as C503				
	C531	CAPACITOR, El Can 3500 μ F, 25V	99392	23C25TA352	106458	2
	C532	Same as C531				
	C533	Same as C502				
	C534	Same as C502				
	C535	CAPACITOR, El Can 100 μ F, 15V	29309	12-4378BP100-15S	106469	1
	C536	Same as C503				
	C537	CAPACITOR, Ceramic .01 μ F 20%, 500V	91418	TYPE SM	100075	1
	C538	CAPACITOR, Tant 47 μ F 20%, 20V	56289	196D476X020LA1	106514	1
	CR501	DIODE, Rectifier	14099	SSIM	106555	12
	CR502	Same as CR501				
	CR503	Same as CR501				
	CR504	Same as CR501				
	CR505	DIODE, Zener 4.7V	03877	1N750	100388	1
	CR506	DIODE, Zener	04713	1N972B	112133	1
	CR507	DIODE, Zener 10V	04713	1N758A	720459	4
	CR508	DIODE, Reference 9V	04713	1N936	106551	1
	CR521	Same as CR501				
	CR522	Same as CR501				
	CR523	Same as CR501				
	CR524	Same as CR501				
	CR525	Same as CR507				
	CR526	Same as CR507				
	CR527	Same as CR507				

REPLACEABLE PARTS LIST

TITLE 150 POWER SUPPLIES AND REGULATORS PC ASSEMBLY #37000913 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	CR531	Same as CR501				
	CR532	Same as CR501				
	CR533	Same as CR501				
	CR534	Same as CR501				
	Q501	TRANSISTOR, SIPNP 25V	07263	MPS3638-5	101360	1
	Q502	TRANSISTOR, SINPN 60V	07263	2N3055	106605	3
	Q503	TRANSISTOR, SINPN	07263	2N2219A	106587	4
	Q504	TRANSISTOR, SINPN	56289	TZ-82	106610	5
	Q505	Same as Q502				
	Q506	Same as Q503				
	Q507	Same as Q504				
	Q508	Same as Q502				
	Q509	Same as Q503				
	Q510	Same as Q504				
	Q511	Same as Q503				
	Q512	Same as Q504				
	Q513	Same as Q504				
	Q514	TRANSISTOR, SIPNP	04713	2N4918	101387	1
	Q515	TRANSISTOR, SIPNP	04713	2N2904A	106572	1
	Q516	TRANSISTOR, SIPNP	07263	2N5087	106575	1
	R501	RESISTOR, CC 5.6 k 5%, 1/4W	01121	CB5625	101584	3
	R502	RESISTOR, CC 200 Ω 5%, 1/4W	01121	CB2015	101555	1
	R503	Same as R501				
	R504	RESISTOR, WW 1 Ω 5%, 3W	15915	TS2D	630030	4
	R505	RESISTOR, CC 120 Ω 5%, 1/4W	01121	CB1215	101717	2
	R506	RESISTOR, CC 3.3 k 5%, 1/4W	01121	CB3325	101559	2
	R507	RESISTOR, CC 82 Ω 5%, 1/4W	01121	CB8205	101629	5
	R508	RESISTOR, MF 2.2 k 5%, 1/2W	16299	RL20	106281	1
	R509	RESISTOR, MF 1.62 k 1%, 1/8W	91637	MFF 1/8 T1	102195	1
	R510	RESISTOR, Variable 250 Ω 10%, 1/2W	01121	SV2511	106127	1

REPLACEABLE PARTS LIST

TITLE						
150 POWER SUPPLIES AND REGULATORS PC ASSEMBLY #37000913 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R511	RESISTOR, MF 825 Ω 1%, 1/8W	81349	RN60C8250F	106202	1
	R521	Same as R501				
	R522	Same as R504				
	R523	Same as R505				
	R524	Same as R506				
	R525	Same as R507				
	R526	RESISTOR, MF 10 k 1%, 1/8W	81349	RN60C1002F	106162	4
	R527	RESISTOR, Variable 1 k 10%, 1/2W	01121	SV1021	106121	1
	R528	Same as R526				
	R530	Same as R504				
	R531	Same as R504				
	R532	RESISTOR, CC 470 Ω 5%, 1/4W	01121	CB4715	101625	1
	R533	RESISTOR, CC 1.6 k 5%, 1/4W	01121	CB1625	101614	1
	R534	RESISTOR, WW 2.7 Ω 5%, 3W	44655	4341	106078	1
	R535	RESISTOR, CC 510 Ω 5%, 1/4W	01121	CB5115	101616	1
	R536	RESISTOR, CC 1.5 k 5%, 1/4W	01121	CB1525	101577	1
	R537	Same as R507				
	R538	Same as R507				
	R539	Same as R526				
	R540	RESISTOR, MF 2.49 k 1%, 1/4W	16299	NA60	106230	1
	R541	Same as R526				
	R542	RESISTOR, MF 2 k 1%, 1/4W	16299	NA60	106224	1
	R543	RESISTOR, CC 6.2 Ω 5%, 1/2W	01121	EB62G5	106017	1
	R544	RESISTOR, CC 300 Ω 5%, 1/4W	01121	CB3015	101537	1
	R545	RESISTOR, CC 1.2 k 5%, 1/4W	01121	CB1225	101581	1
	R546	Same as R507				

REPLACEABLE PARTS LIST

TITLE 150 POWER SUPPLIES AND REGULATORS PC ASSEMBLY #37000913 (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	R547	RESISTOR, MF 11.5 k 1%, 1/8W	91637	MFF 1/8 T2	102041	1
	R548	RESISTOR, MF 1 k 1%, 1/8W	19701	MF5C-D-1001F	102097	1
	Z501	INTEGRATED CIRCUIT Operational Amplifier	07263	μ A741TC	106621	5
	Z502	Same as Z501				
	Z503	Same as Z501				
	Z504	Same as Z501				
	Z505	Same as Z501				

REPLACEABLE PARTS LIST

TITLE LINEAR D/A CONVERTER PC ASSEMBLY (Model 153/154-1 Positive True, P/N 37001-145, Model 153/154-1 Ground True, P/N 37001-144, Model 153/154-3 Positive True & Ground True P/N 37001-146)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	C1	CAPACITOR, Eramic .022 μ F 25%, 25V	71590	2DDU60E223M	106483	6
	C2	Same as C1				
	C3	Same as C1				
	C4	Same as C1				
	C5	Same as C1				
	C6	Same as C1				
	C7	CAPACITOR, Tant 6.8 μ F 20%, 35V	56289	196D685X0035E1	106515	1
	C8	CAPACITOR, Tant 22 μ F 20%, 20V	31433	T362C226M025AS	112281	2
	C9	Same as C8				
	CR1 thru CR13	DIODE, Silicon	07263	1N4150/1N3600	112127	13
	Q1 thru Q12	TRANSISTOR, SINPN 30V	07263	PN3641-5	106586	12
	R1	RESISTOR, CC 1.8 k 5%, 1/4W	01121	CB1825	101602	16
	R2	RESISTOR, CC 1.3 k 5%, 1/4W	01121	CB1325	101556	12
	R3	RESISTOR, MF 23.7 k .5%, 1/8W	81349	RN60C	106339	1
	R4	Same as R1				
	R5	Same as R2				
	R6	RESISTOR, MF 12.1 k .5%, 1/8W	81349	RN60C	106337	1
	R7	Same as R1				
	R8	Same as R2				
	R9	RESISTOR, MF 5.8 k .5%, 1/8W	81349	RN60C	106344	1
	R10	Same as R1				
	R11	Same as R2				
	R12	RESISTOR, MF 3.01 k .5%, 1/8W	81349	RN65C3011D	106209	1
	R13	Same as R1				
	R14	Same as R2				

REPLACEABLE PARTS LIST

TITLE LINEAR D/A CONVERTER PC ASSEMBLY (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	R15	RESISTOR, MF 237 k 1%, 1/8W	16299	NA60C	106227	1
	R16	Same as R1				
	R17	Same as R2				
	R18	RESISTOR, MF 121 k 1%, 1/8W	16299	NA60	106216	1
	R19	Same as R1				
	R20	Same as R2				
	R21	RESISTOR, MF 59 k 1%, 1/8W	16299	NA60	106253	1
	R22	Same as R1				
	R23	Same as R2				
	R24	RESISTOR, MF 30.1 k .5%, 1/8W	16299	NA60	106237	1
	R25	Same as R1				
	R26	Same as R2				
	R27	RESISTOR, CC 2.4 M 5%, 1/4W	01121	CB2455	106002	1
	R28	Same as R1				
	R29	Same as R2				
	R30	RESISTOR, CC 1.3 M 5%, 1/4W	01121	CB1355	106000	1
	R31	Same as R1				
	R32	Same as R2				
	R33	RESISTOR, CC 620 k 5%, 1/4W	01121	CB6245	101619	1
	R34	Same as R1				
	R35	Same as R2				
	R36	RESISTOR, CC 300 k 5%, 1/4W	01121	CB3045	101620	1
	R37	Same as R1				
	R38	Same as R1				
	R39	Same as R1				
	R40	Same as R1				
	R41	RESISTOR, CC 510 k 5%, 1/4W	01121	CB5145	101611	1
	R42	RESISTOR, CC 130 k 5%, 1/4W	01121	CB1345	101603	1

REPLACEABLE PARTS LIST

TITLE						
LINEAR D/A CONVERTER PC ASSEMBLY (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R43	RESISTOR, CC 5.1 M 5%, 1/4W	01121	CB5155	101692	1
	R44	Same as R30				
	Z1	INTEGRATED CIRCUIT, TTL Hex Inverter (positive true parallel only)	01295	SN7416N	045230	3
	Z2	Same as Z1				
	Z3	Same as Z1				
	Z1	INTEGRATED CIRCUIT, TTL Hex Buffer (ground true parallel only)	01295	SN7417N	106629	3
	Z2	Same as Z1				
	Z3	Same as Z1				
	Z4	INTEGRATED CIRCUIT, TTL Quad Latch (serial to parallel only)	01295	SN7475N	019710	4
	Z5	Same as Z4				
	Z6	Same as Z4				
	Z7	Same as Z4				

REPLACEABLE PARTS LIST

TITLE HYPERBOLIC D/A CONVERTER PC ASSEMBLY (P/N 37001-147, P/N 37001-148, P/N 37001-149)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	C1	CAPACITOR, Ceramic .022 μ F 25%, 25V	71590	2DDU60E22M	106483	6
	C2	Same as C1				
	C3	Same as C1				
	C4	Same as C1				
	C5	Same as C1				
	C6	Same as C1				
	C7	CAPACITOR, Tant 4.7 μ F, 20V	56289	196D475X0035JA1	106513	1
	C8	CAPACITOR, Ceramic .01 μ F 20%, 500V	91418	TYPE SM	100075	1
	C9	CAPACITOR, Tant 6.8 μ F 20%, 35V	56289	196D685X035E1	106515	2
	C10	CAPACITOR, Tant 22 μ F 20%, 20V	31433	T362C226M025AS	112281	3
	C11	Same as C9				
	C12	Same as C10				
	C13	Same as C10				
	CR1	DIODE, Silicon	07263	1N4150/1N3600	112127	5
	CR2	Same as CR1				
	CR3	Same as CR1				
	CR4	Same as CR1				
	CR5	Same as CR1				
	Q1	TRANSISTOR, SINPN 30V	07263	PN3641-5	106586	12
	Q2	TRANSISTOR, SIPNP	07263	2N5087	106575	14
	Q3	Same as Q1				
	Q4	Same as Q2				
	Q5	Same as Q1				
	Q6	Same as Q2				
	Q7	Same as Q1				
	Q8	Same as Q2				
	Q9	Same as Q1				
	Q10	Same as Q2				
	Q11	Same as Q1				
	Q12	Same as Q2				
	Q13	Same as Q1				
	Q14	Same as Q2				

REPLACEABLE PARTS LIST

TITLE HYPERBOLIC D/A CONVERTER PC ASSEMBLY (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	Q15	Same as Q1				
	Q16	Same as Q2				
	Q17	Same as Q1				
	Q18	Same as Q2				
	Q19	Same as Q1				
	Q20	Same as Q2				
	Q21	Same as Q1				
	Q22	Same as Q2				
	Q23	Same as Q1				
	Q24	Same as Q2				
	Q25	TRANSISTOR, SINPN	56289	TZ82	106610	1
	Q26	Same as Q2				
	Q27	TRANSISTOR, SIPNP	56289	TD401	106615	1
	Q28	Same as Q2				
	R1	RESISTOR, CC 1 k 5%, 1/4W	01121	CB1025	101569	12
	R2	RESISTOR, CC 5.1 k 5%, 1/4W	01121	CB5125	101541	12
	R3	RESISTOR, CC 24 k 5%, 1/4W	01121	CB2435	101554	12
	R4	RESISTOR, MF 10.2 k .5%, 1/8W	81349	RN60C	106336	1
	R5	RESISTOR, CC 3.6 k 5%, 1/4W	01121	CB3625	101600	16
	R6	Same as R1				
	R7	Same as R2				
	R8	Same as R3				
	R9	RESISTOR, MF 5.1 k .5%, 1/8W	81349	RN60C	106343	1
	R10	Same as R5				
	R11	Same as R1				
	R12	Same as R2				
	R13	Same as R3				
	R14	RESISTOR, MF 2.55 k .5%, 1/8W	81349	RN60C	106340	1
	R15	Same as R5				
	R16	Same as R1				
	R17	Same as R2				

REPLACEABLE PARTS LIST

TITLE HYPERBOLIC D/A CONVERTER PC ASSEMBLY (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	R18	Same as R3				
	R19	RESISTOR, MF 1.275 k .5%, 1/8W	81349	RN60C	106338	1
	R20	Same as R5				
	R21	Same as R1				
	R22	Same as R2				
	R23	Same as R3				
	R24	RESISTOR, MF 102 k 1%, 1/8W	81349	RN60C1023F	106207	1
	R25	Same as R5				
	R26	Same as R1				
	R27	Same as R2				
	R28	Same as R3				
	R29	RESISTOR, MF 51.1 k 1%, 1/8W	81349	RN60C5112F	106192	1
	R30	Same as R5				
	R31	Same as R1				
	R32	Same as R2				
	R33	Same as R3				
	R34	RESISTOR, MF 25.5 k 1%, 1/8W	81349	RN60C2552F	106176	1
	R35	Same as R5				
	R36	Same as R1				
	R37	Same as R2				
	R38	Same as R3				
	R39	RESISTOR, MF 12.7 k 1%, 1/8W	81349	RN60C1272F	106165	1
	R40	Same as R5				
	R41	Same as R1				
	R42	Same as R2				
	R43	Same as R3				
	R44	RESISTOR, CC 1 M 5%, 1/5W	01121	CB1055	101605	1
	R45	Same as R5				
	R46	Same as R1				
	R47	Same as R2				
	R48	Same as R3				

REPLACEABLE PARTS LIST

TITLE HYPERBOLIC D/A CONVERTER PC ASSEMBLY (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R49	RESISTOR, CC 510 k 5%, 1/4W	01121	CB5145	101611	1
	R50	Same as R5				
	R51	Same as R1				
	R52	Same as R2				
	R53	Same as R3				
	R54	RESISTOR, MF 255 k 1%, 1/8W	81349	RN60C2553F	106177	1
	R55	Same as R5				
	R56	Same as R1				
	R57	Same as R2				
	R58	Same as R3				
	R59	RESISTOR, CC 130 k 5%, 1/4W	01121	CB1345	101603	1
	R60	Same as R5				
	R61	Same as R5				
	R62	Same as R5				
	R63	Same as R5				
	R64	Same as R5				
	R65	RESISTOR, Variable 250k 10%, 1/2W	72138	89PR250K	106137	1
	R66	RESISTOR, MF 100 k 1%, 1/8W	81349	RN60E1003F	101967	1
	R67	RESISTOR, MF 1 k 1%, 1/8W	81349	RN60C1001F	106161	1
	R68	RESISTOR, MF 5 k .1%, 1/8W	81349	RN60C	106355	1
	R69	RESISTOR, CC 620 Ω 5%, 1/4W	01121	CB6215	101688	1
	R70	RESISTOR, CC 300 Ω 5%, 1/4W	01121	CB3015	101537	1
	R71	RESISTOR, MF 1.82 k 1%, 1/8W	81349	RN60C1821F	106170	1
	R72	RESISTOR, Variable 500 Ω 10%, 3/8W	72138	79PR500	102183	1
	R73	RESISTOR, CC 100 Ω 5%, 1/4W	01121	CB1015	101609	1
	R74	RESISTOR, MF 15 k 1%, 1/8W	81349	RN60C1502F	106169	1

REPLACEABLE PARTS LIST

TITLE HYPERBOLIC D/A CONVERTER PC ASSEMBLY (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	Z1	INTEGRATED CIRCUIT, TTL Hex Inverter (ground true parallel only)	01295	SN7416N	045230	3
	Z2	Same as Z1				
	Z3	Same as Z1				
	Z1	INTEGRATED CIRCUIT, TTL Hex Buffer (positive true parallel only)	01295	SN7417N	106629	3
	Z2	Same as Z1				
	Z3	Same as Z1				
	Z4	INTEGRATED CIRCUIT, TTL Quad Latch (serial to parallel only)	01295	SN7475N	019710	4
	Z5	Same as Z4				
	Z6	Same as Z4				
	Z7	Same as Z4				

REPLACEABLE PARTS LIST

TITLE HYPERBOLIC CONDUCTANCE D/A CONVERTER (P/N 37001-430, P/N 37001-431, P/N 37001-432)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	C1	CAPACITOR, Tant 22 μ F 20%, 20V	31433	T362C226MO25AS	112281	2
	C2	CAPACITOR, Ceramic .022 μ F 25%, 25V	71590	2DDU60E223M	106483	8
	C3	Same as C2				
	C4	Same as C2				
	C5	Same as C2				
	C6	Same as C2				
	C7	Same as C2				
	C8	Same as C2				
	C9	Same as C2				
	C10	Same as C1				
	Q1 thru Q12	TRANSISTOR, Selected	52542	112154	112154	12
	R1	RESISTOR, CC 2.2 k 5%, 1/4W	01121	CB2225	101562	28
	R2	Same as R1				
	R3	RESISTOR, MF 51 k .1%, 1/8W	81349	RN60C	106359	2
	R4	Same as R1				
	R5	Same as R1				
	R6	RESISTOR, MF 5.1 k .1%, 1/8W	81349	RN60C	106358	1
	R7	RESISTOR, CC 13 M 5%, 1/4W	01121	CB1365	112473	1
	R8	Same as R1				
	R9	Same as R1				
	R10	RESISTOR, MF 2.550 k .1%, 1/8W	81349	RN60C	106351	1
	R11	RESISTOR, CC 1.3 M 5%, 1/4W	01121	CB1355	106000	1
	R12	Same as R1				
	R13	Same as R1				
	R14	RESISTOR, MF 1.275 k .1%, 1/8W	81349	RN60C	106350	1
	R15	RESISTOR, CC 820 k 5%, 1/4W	01121	CB8245	101850	1

REPLACEABLE PARTS LIST

TITLE						
HYPERBOLIC CONDUCTANCE D/A CONVERTER (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/O
	R16	Same as R1				
	R17	RESISTOR, MF 102 k .1%, 1/8W	81349	RN60C	106349	1
	R18	Same as R1				
	R19	Same as R1				
	R20	Same as R1				
	R21	Same as R3				
	R22	Same as R1				
	R23	RESISTOR, MF 23.153 k .1%, 1/8W	81349	RN60C	106352	1
	R24	Same as R1				
	R25	Same as R1				
	R26	Same as R1				
	R27	RESISTOR, MF 12.75 k .1%, 1/8W	81349	RN60C	112287	1
	R28	Same as R1				
	R29	RESISTOR, MF 1 M 1%, 1/8W	81349	RN60C1004F	106163	1
	R30	Same as R1				
	R31	Same as R1				
	R32	Same as R1				
	R33	RESISTOR, MF 511 k 1%, 1/8W	81349	RN60C5113F	106193	1
	R34	Same as R1				
	R35	RESISTOR, MF 255 k 1%, 1/8W	81349	RN60C2553F	106177	1
	R36	Same as R1				
	R37	Same as R1				
	R38	Same as R1				
	R39	RESISTOR, MF 127 k 1%, 1/8W	81349	RN60C1273F	106166	1
	R40	Same as R1				
	R41	Same as R1				
	R42	Same as R1				
	R43	Same as R1				
	Z4	INTEGRATED CIRCUIT, TTL Quad Latch (positive true parallel only)	01295	SN7475N	019710	4
	Z5	Same as Z4				

REPLACEABLE PARTS LIST

TITLE						
HYPERBOLIC CONDUCTANCE D/A CONVERTER (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	Z6	Same as Z1				
	Z7	Same as Z1				
	Z8	INTEGRATED CIRCUIT Hex Inverter (ground true parallel only)	01295	SN7416N	045230	2
	Z9	Same as Z8				

REPLACEABLE PARTS LIST

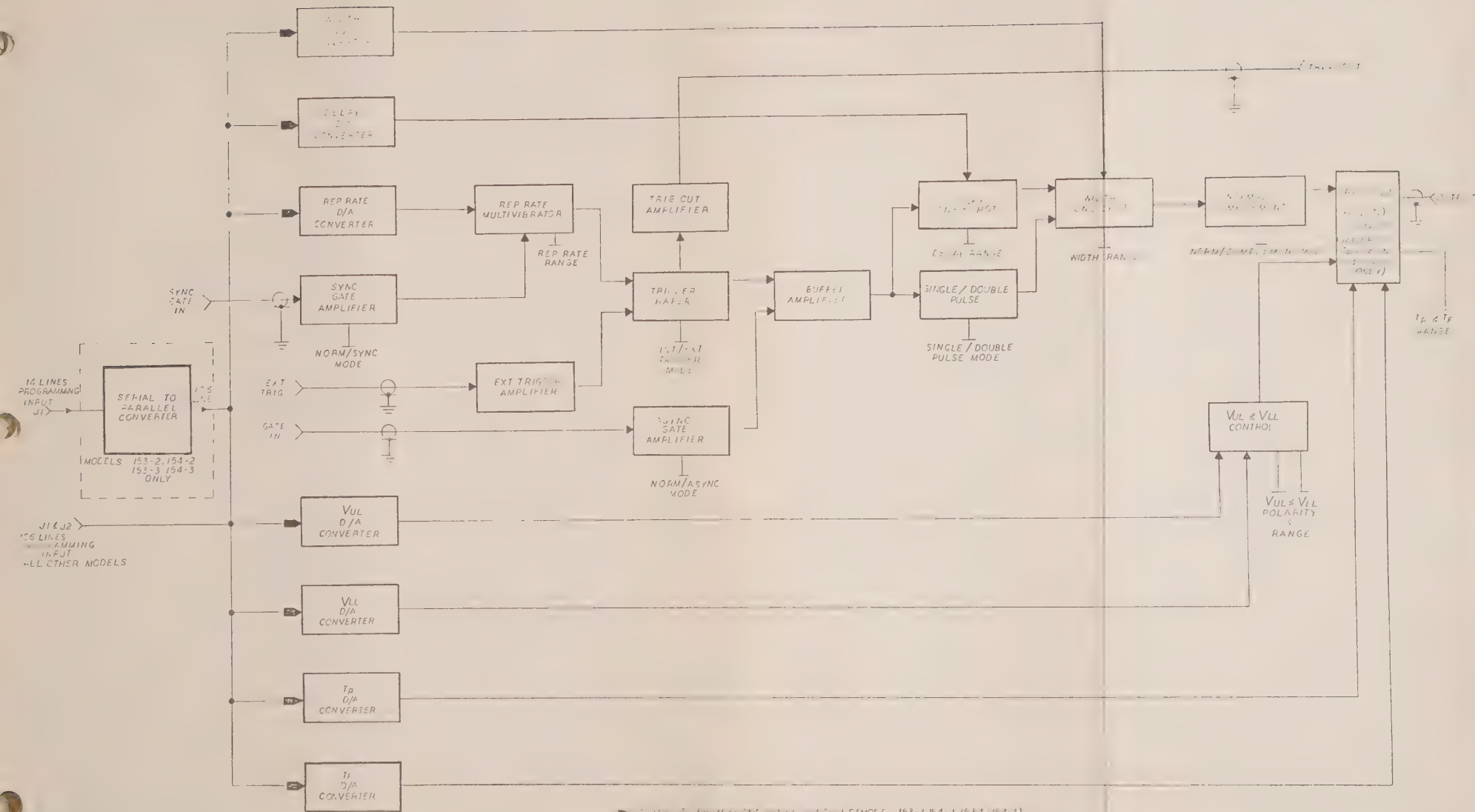
SERIAL TO PARALLEL CONVERTER PC ASSEMBLY (Model 153/154-3 Positive True P/N 37001-151, Model 153/154-3 Ground True P/N 37001-150)							
TITLE	ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
		C1	CAPACITOR, Ceramic .022 μ F 25%, 25V	71590	2DDU60E223M	106483	10
		C2	Same as C1				
		C3	Same as C1				
		C4	Same as C1				
		C5	Same as C1				
		C6	CAPACITOR, MF 270 pF 5%, 500V	72136	DM15FD271JO	100238	2
		C7	Same as C6				
		C8	Same as C1				
		C9	Same as C1				
		C10	Same as C1				
		C11	Same as C1				
		C12	Same as C1				
		C13	CAPACITOR, Tant 22 μ F 20%, 20V	31433	T362C226M025AS	112281	2
		C14	Same as C13				
		C15	CAPACITOR, DM 82 pF 5%, 500V	72136	DM15ED820JO	100172	3
		C16	Same as C15				
		C17	Same as C15				
		CR1	DIODE, Signal	26466	1N995	106548	2
		CR2	Same as CR1				
		R1	RESISTOR, CC 1.8 k 5%, 1/4W	01121	CB1825	101602	25
		R2 thru R8	Same as R1				
		R9	RESISTOR, CC 1 k 5%, 1/4W	01121	CB1025	101569	6
		R10	Same as R9				
		R11	Same as R9				
		R12	Same as R9				
		R13	Same as R9				
		R14	RESISTOR, CC 2.7 k 5%, 1/4W	01121	CB2725	101599	2
		R15	Same as R14				
		R16	Same as R9				

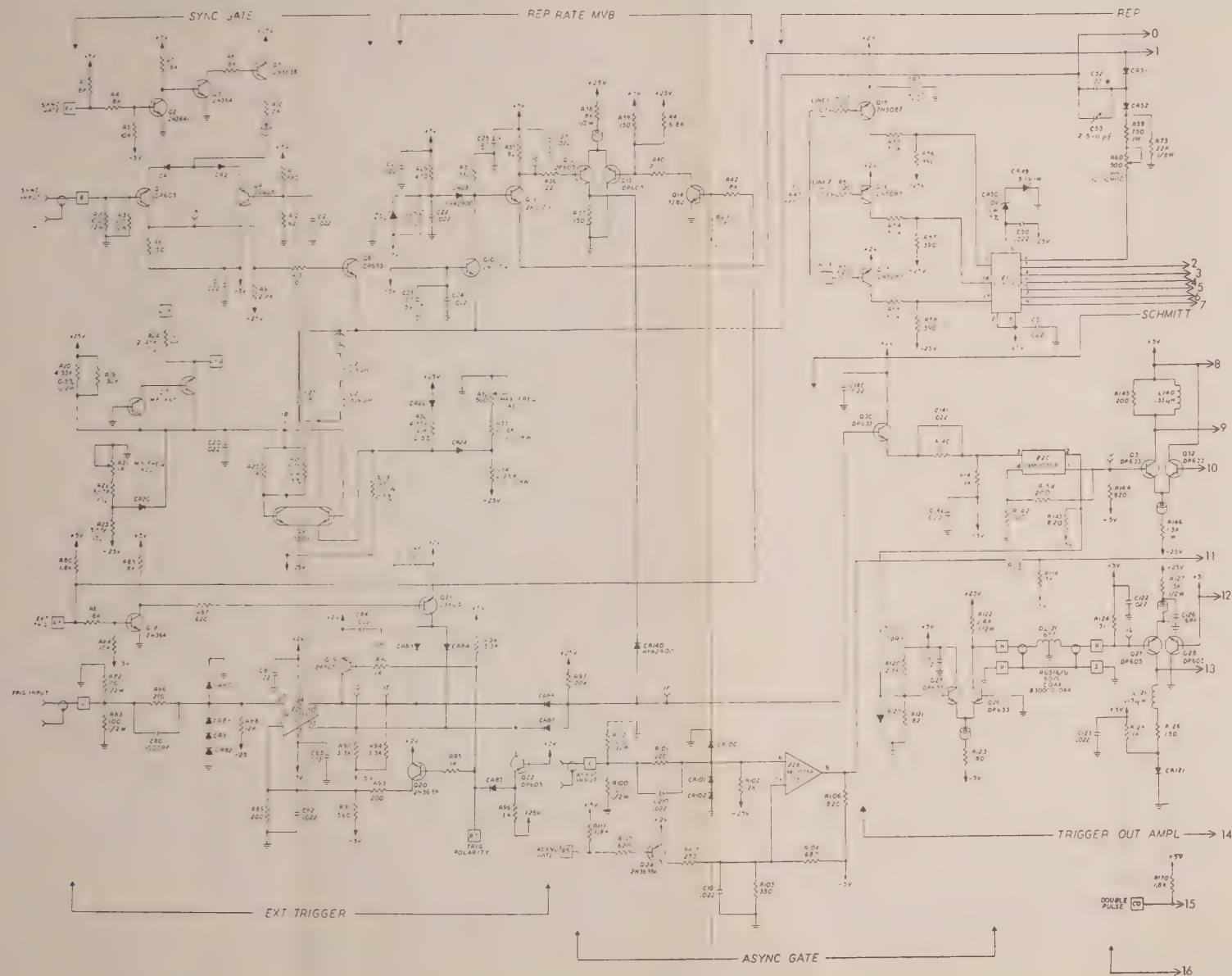
REPLACEABLE PARTS LIST

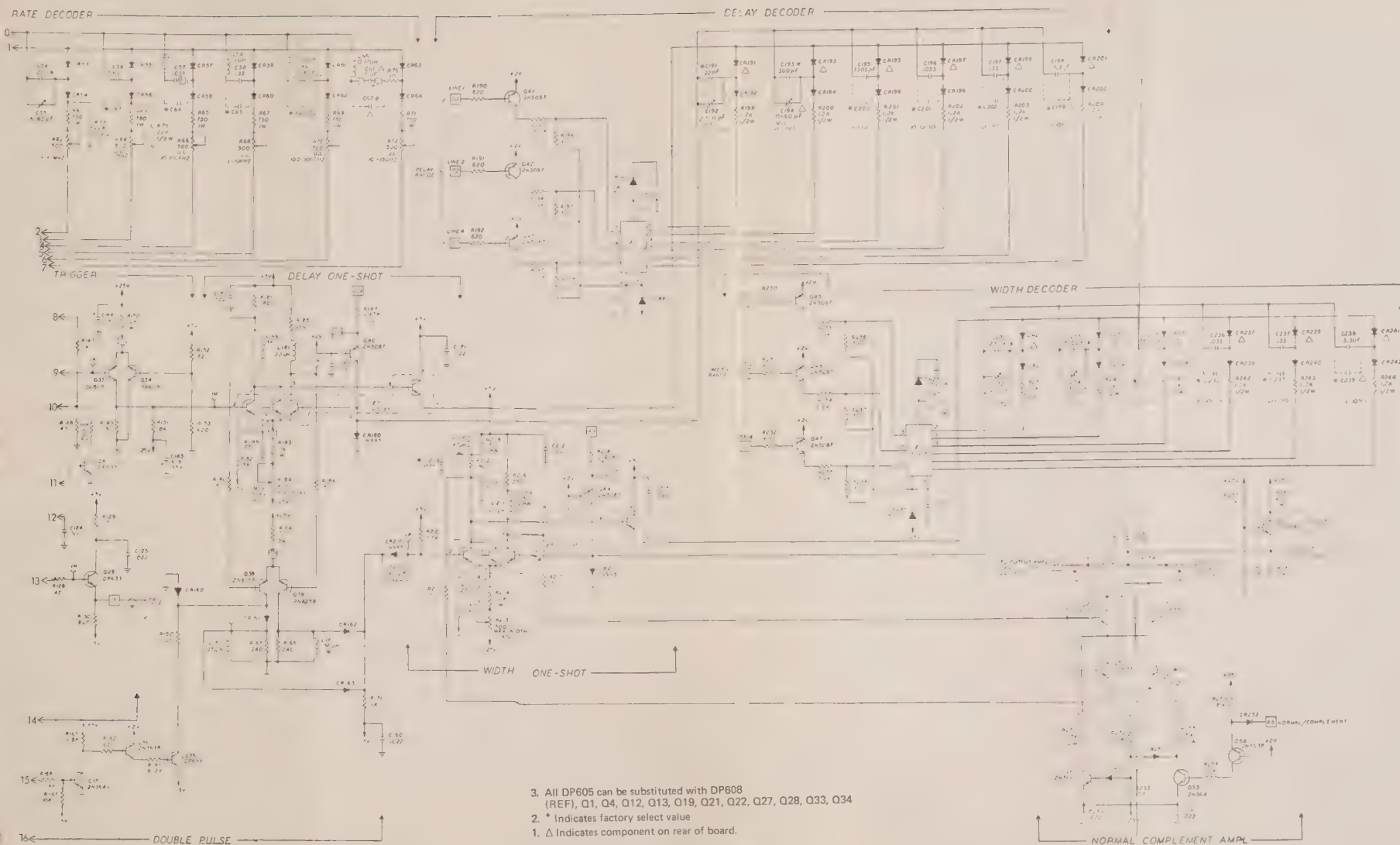
TITLE						
SERIAL TO PARALLEL CONVERTER PC ASSEMBLY (Cont'd)						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	R17 thru R33	Same as R1				
	R34	RESISTOR, CC 100 Ω 5%, 1/4W	01121	CB1015	101609	3
	R35	Same as R34				
	R36	Same as R34				
	Z1	INTEGRATED CIRCUIT, TTL Hex Inverter Buffer(positive true only)	01295	SN7416N	045230	7
	Z2	Same as Z1				
	Z3	Same as Z1				
	Z4	Same as Z1				
	Z5	INTEGRATED CIRCUIT, TTL Quad 2 Input NOR Gate	01295	SN7402N	025709	2
	Z6	Same as Z5				
	Z7	INTEGRATED CIRCUIT, TTL BCD Decimal Decoder/Driver	01295	SN74145	025754	2
	Z8	Same as Z7				
	Z9	Same as Z1				
	Z10	Same as Z1				
	Z11	Same as Z1				
	Z1	INTEGRATED CIUCUIT, TTL Hex Buffer Driver (ground true only)	01295	SN7417N	106629	4
	Z2	Same as Z1				
	Z3	Same as Z1				
	Z4	Same as Z1				

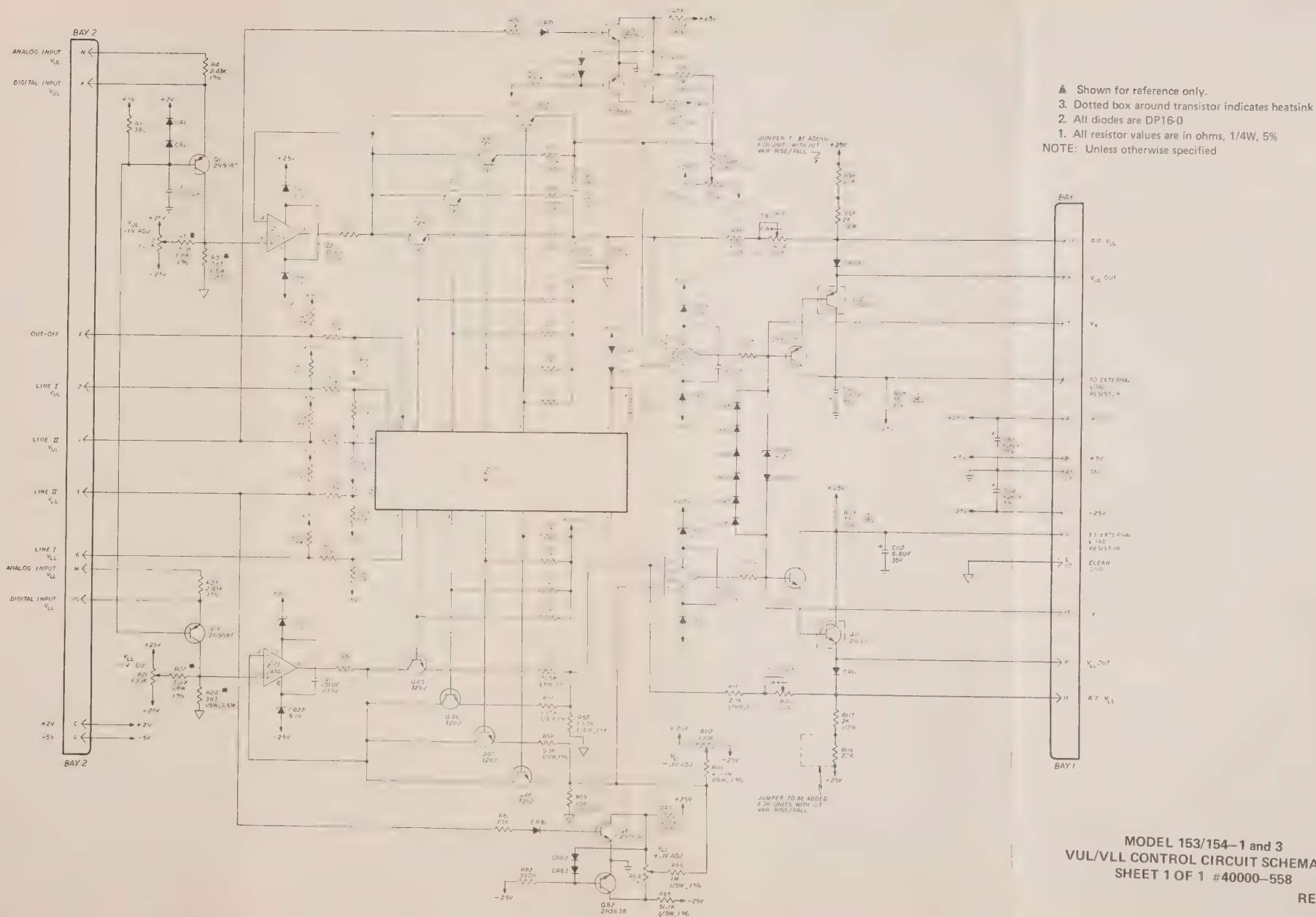
REPLACEABLE PARTS LIST

TITLE BACK PANEL ASSEMBLY - 150 SERIES # 37000-952						
ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	B501	FAN	92702	WS2107F	106664	1
	F501	FUSE, 3A 250V	75915	312003	100587	1
	J1	CONNECTOR	81312	MRAC75-5J6	106733	2
	J2	Same as J1				
	J501	CONNECTOR, AC Input	00779	160-5N	106698	1
	S502	SWITCH, Slide	82389	46256LFR	102331	1
	T501	TRANSFORMER, Power	52542	112171	112171	
		HOLDER, Fuse	71400	HKP	106907	1
		CONNECTOR, BNC	96906	UG-1094/U	101155	5

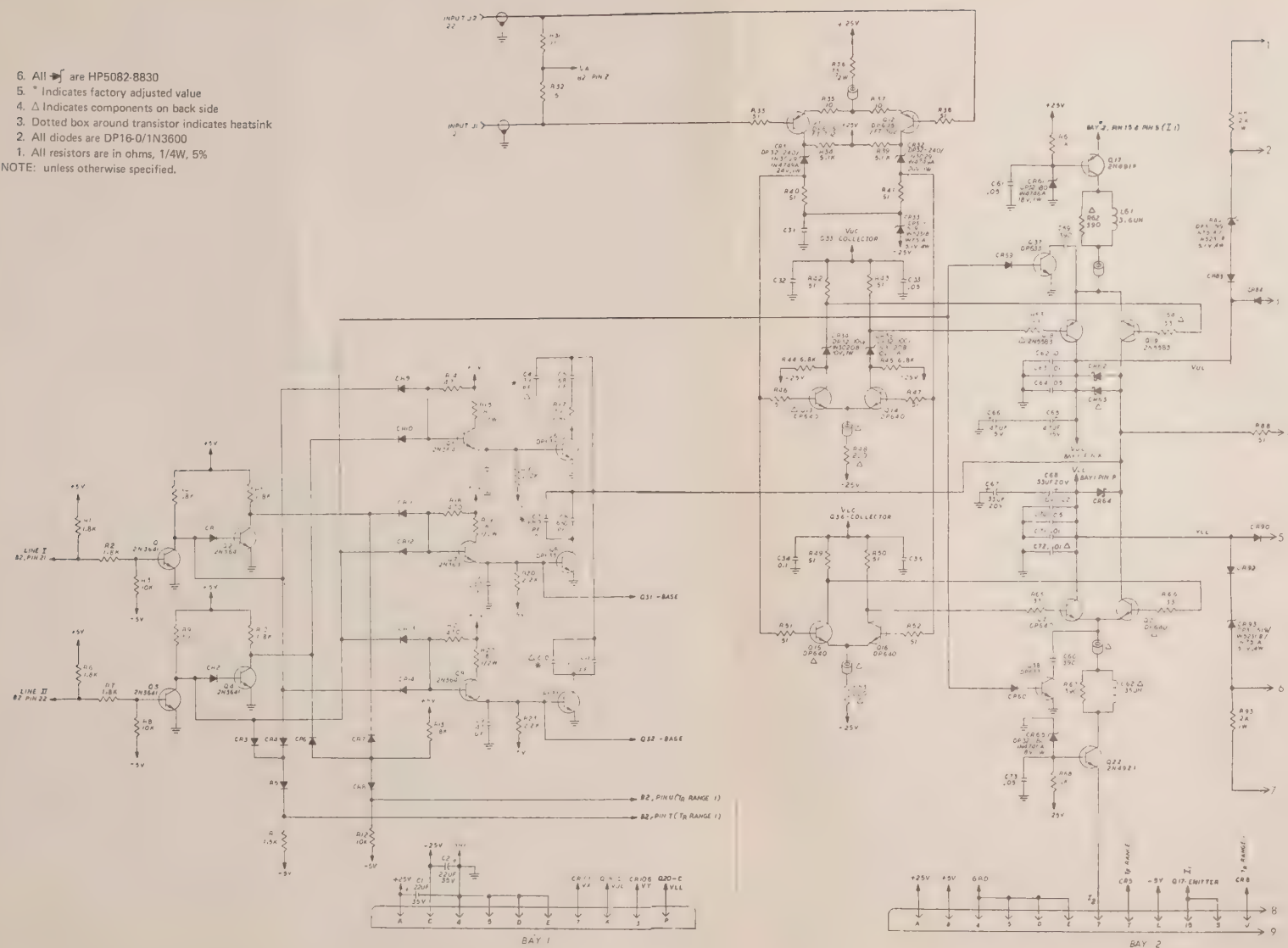


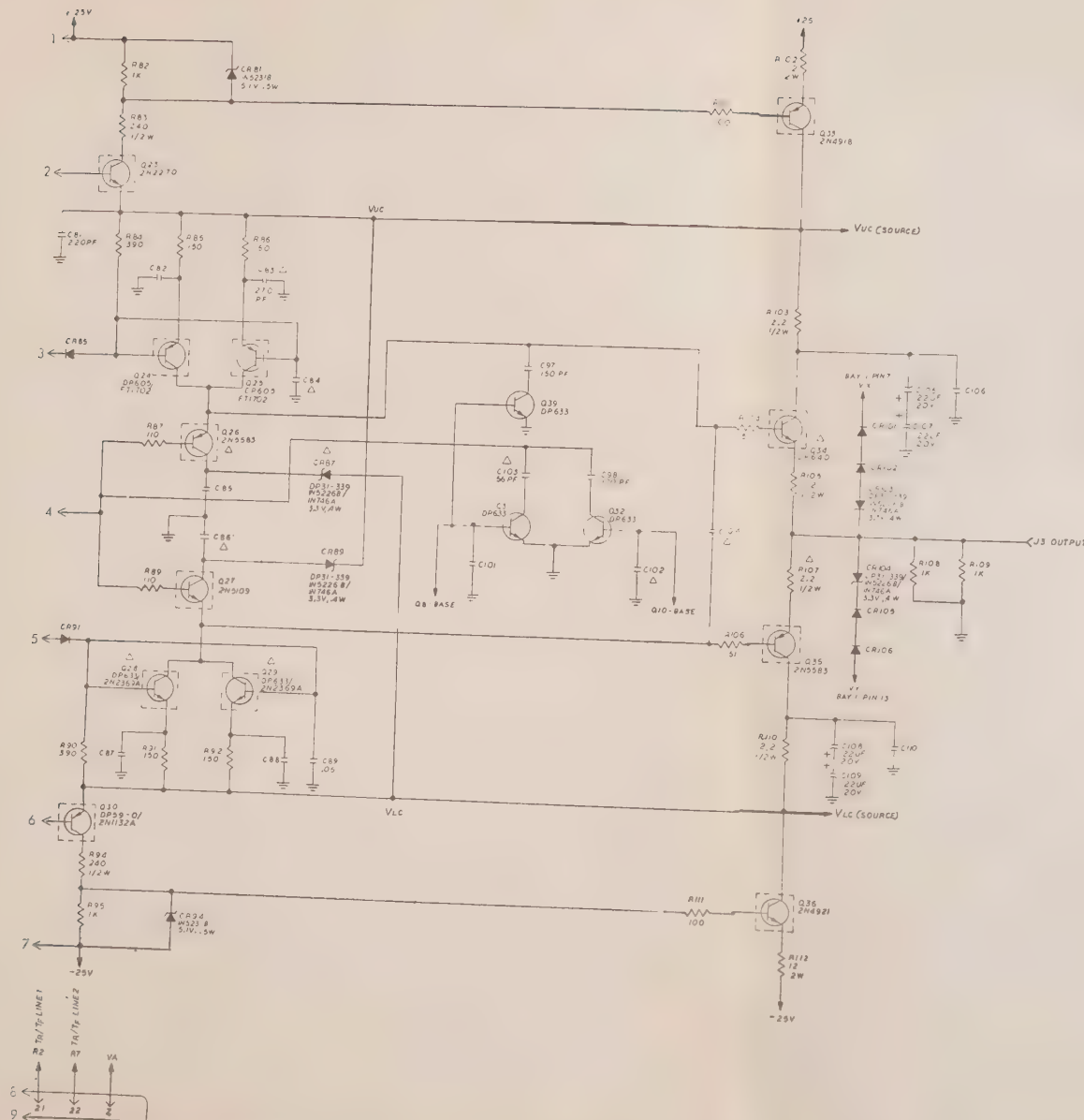


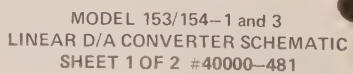




6. All $\rightarrow$ are HP5082-8830
 5. * Indicates factory adjusted value
 4. Δ Indicates components on back side
 3. Dotted box around transistor indicates heatsink
 2. All diodes are DP16-0/1N3600
 1. All resistors are in ohms, 1/4W, 5%
- NOTE: unless otherwise specified.

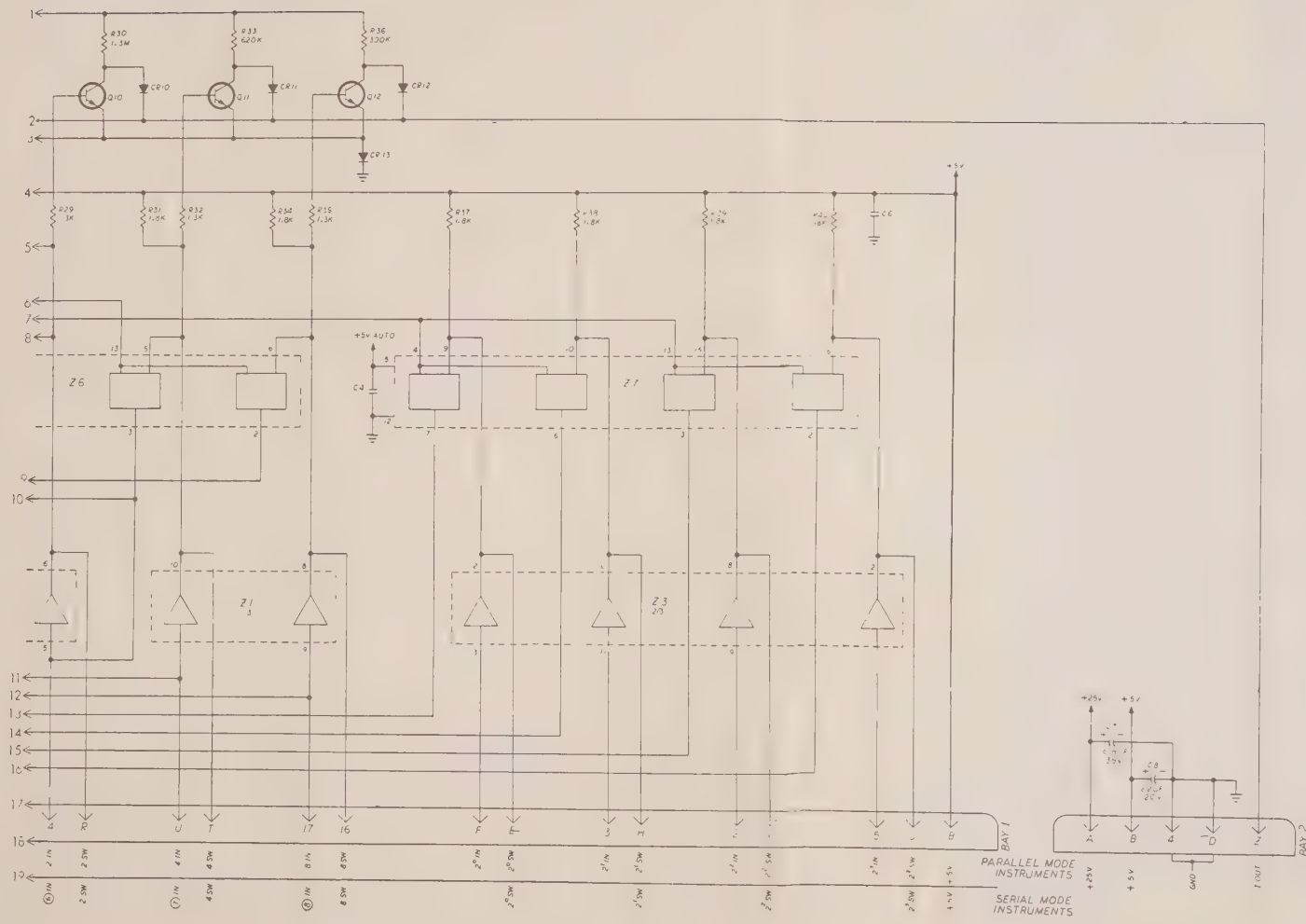


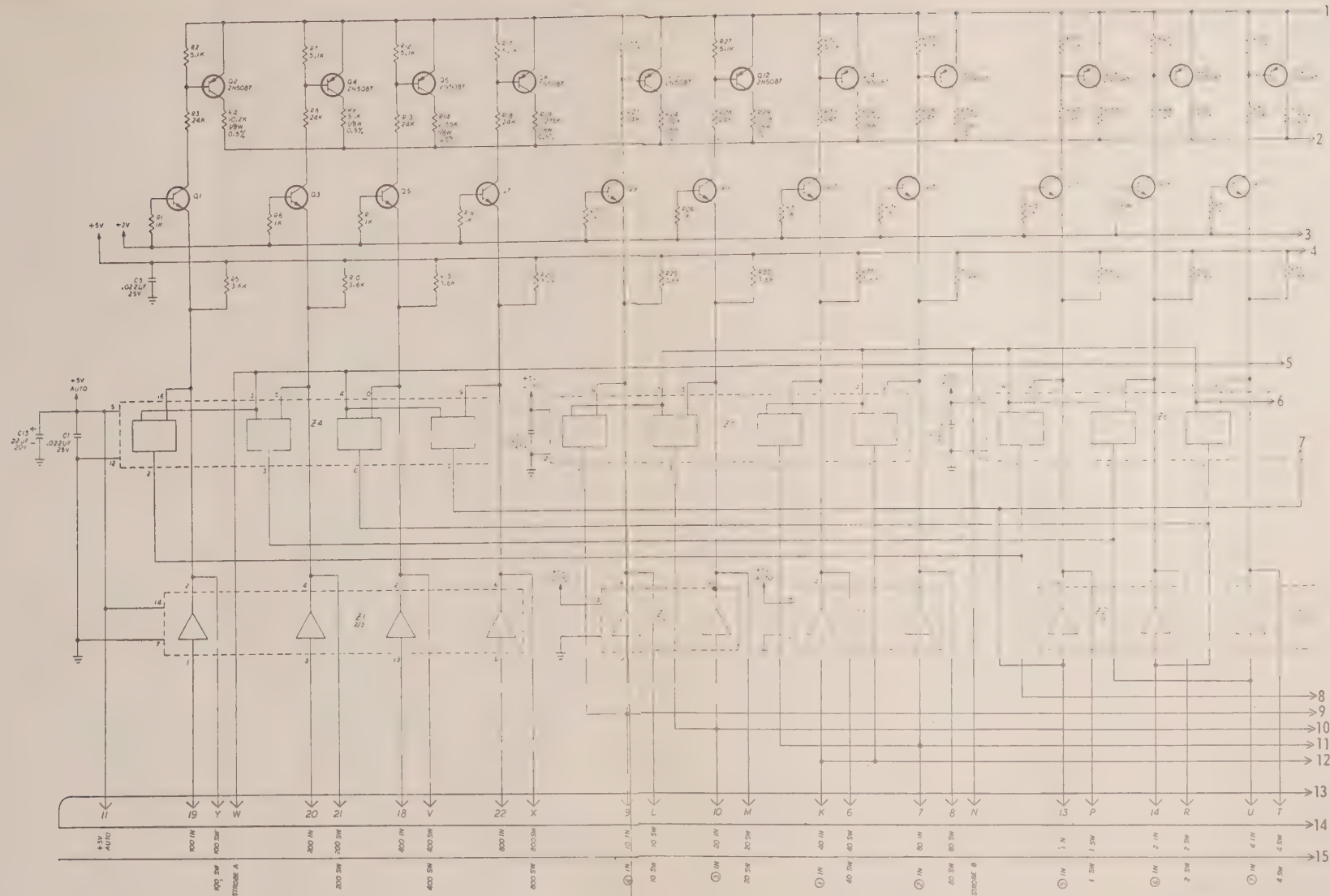


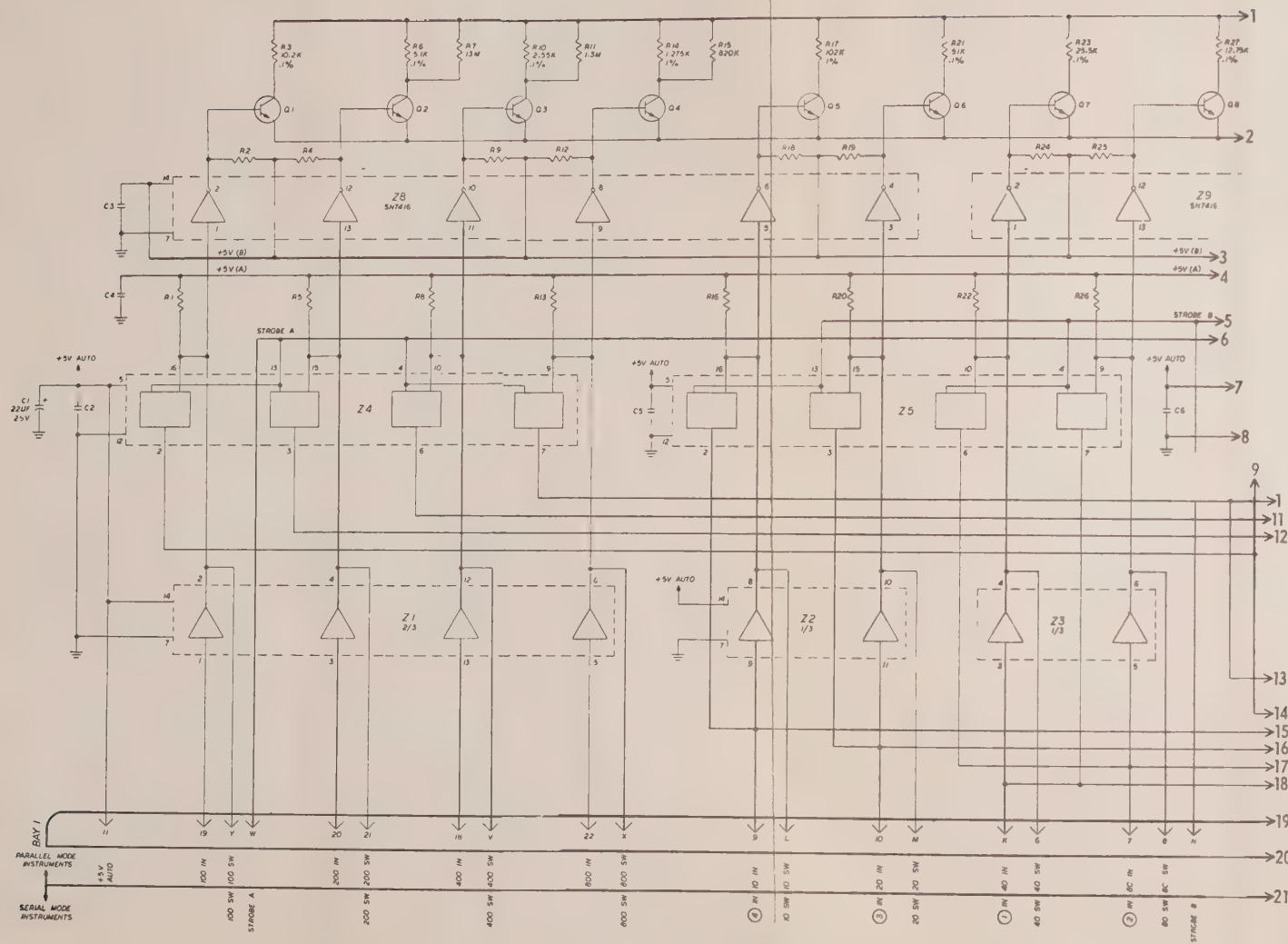


6. For serial to parallel D/A IC's 4-7 are SN7475 and IC 1, 2 & 3 are omitted
7. For parallel to parallel D/A 1, 2 & 3 are SN7416 & IC's 4-7 are omitted
8. For serial to serial parallel D/A IC's 1, 2 & 3 are SN7416 and IC's 4-7 are omitted
3. All transistors are 2N3641/MPS6532
2. All diodes are DP16-0/1N3600
1. All capacitors are .022 μ F, 25V

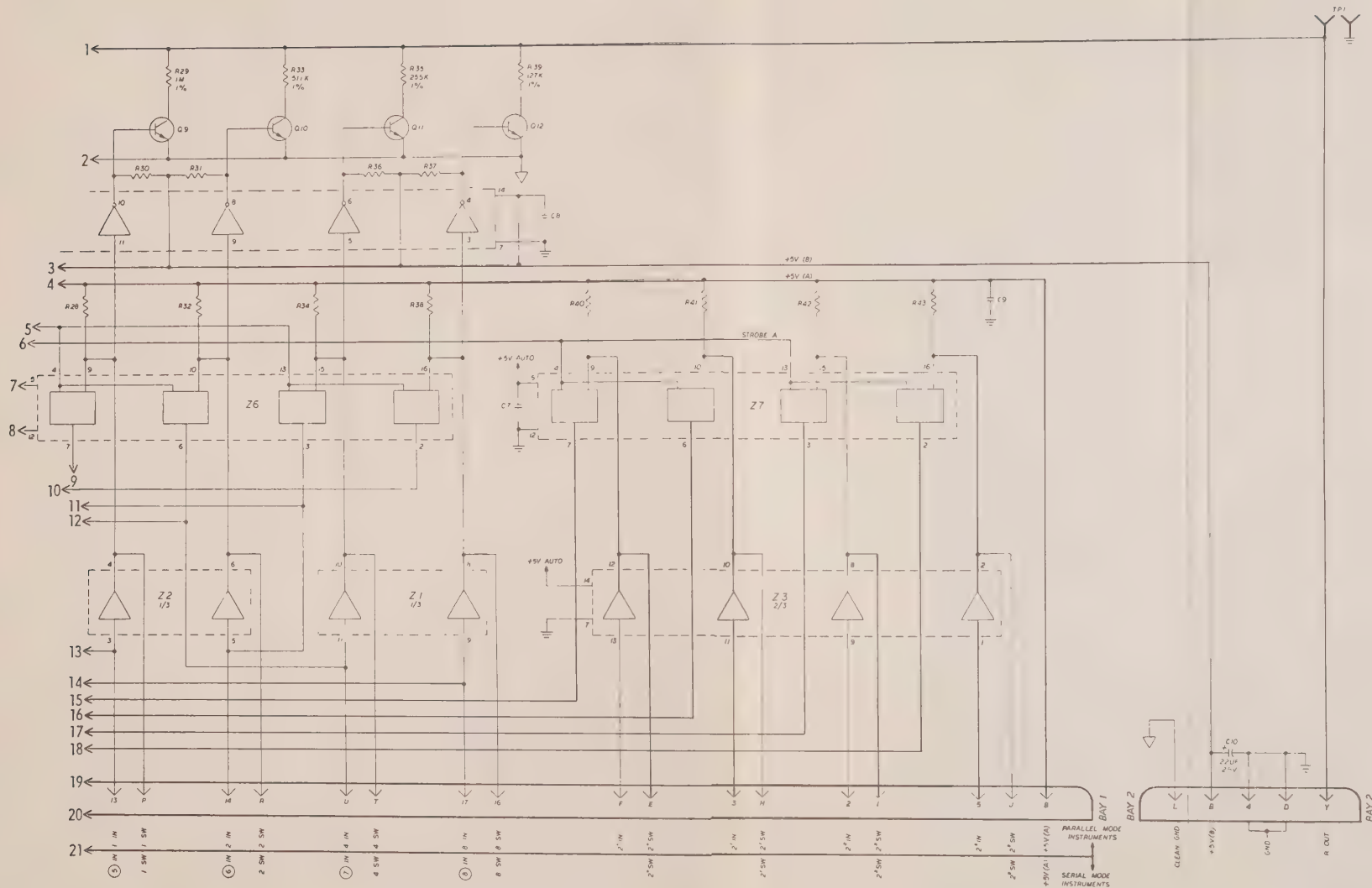
NOTE: Unless otherwise specified



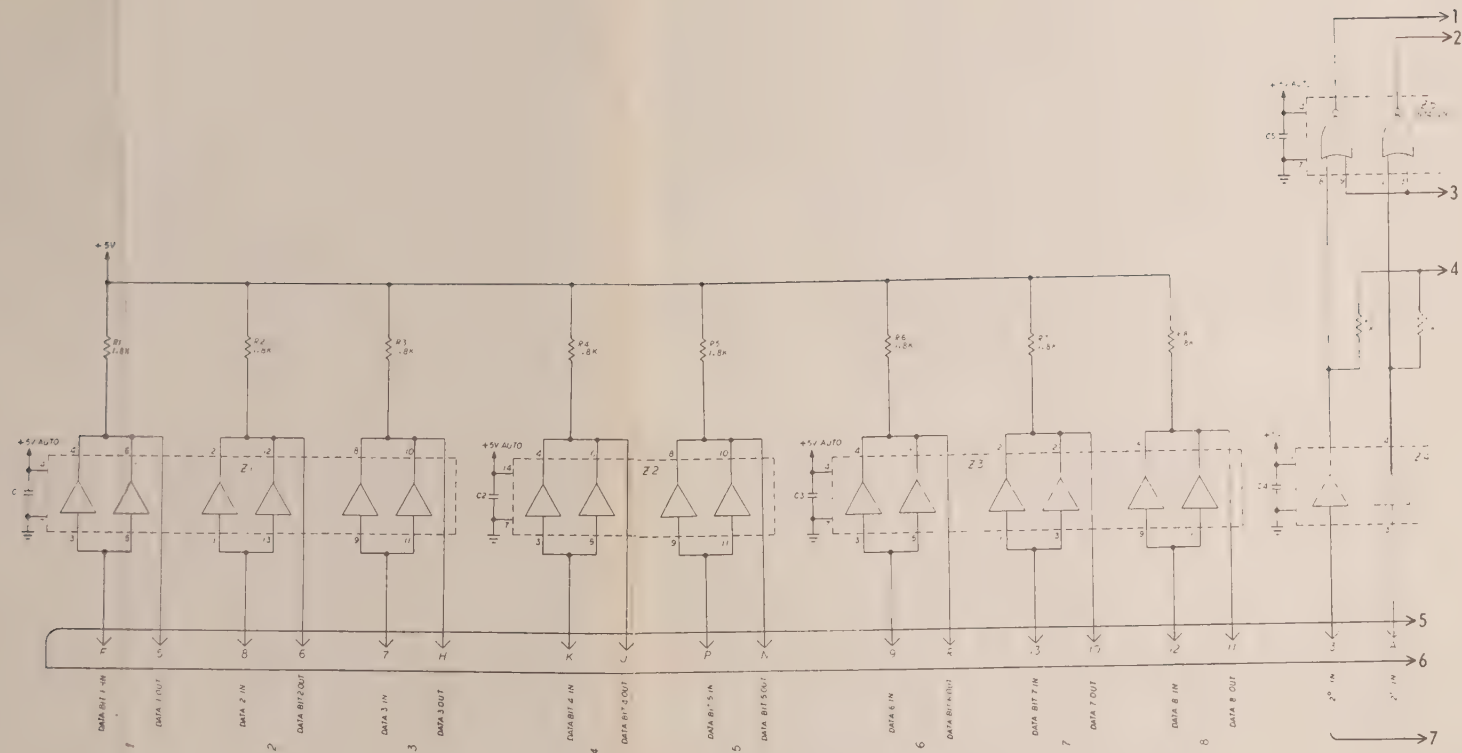




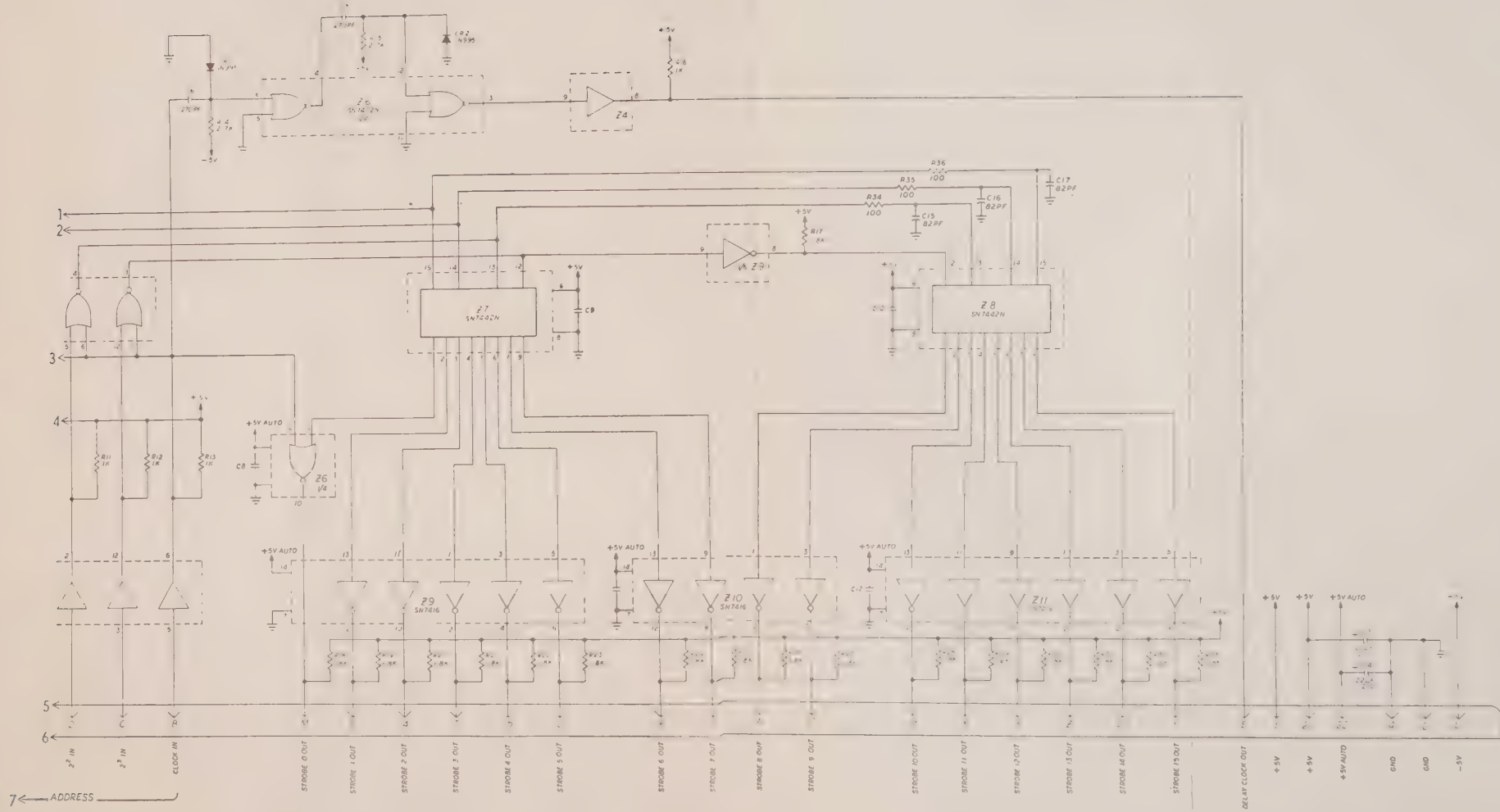
5. For serial to parallel D/A IC's 4-7 are SN7475 and IC's 1, 2 & 3 are omitted
 4. For GND true parallel D/A IC's 1, 2 & 3 are SN7417 and IC's 4-7 are omitted
 3. For positive true parallel D/A IC's 1, 2 & 3 are SN7416 and IC's 4-7 are omitted
 2. All transistors are DP6311
 1. All capacitors are .022 μ F, 25V
- NOTE: . . . less otherwise specified



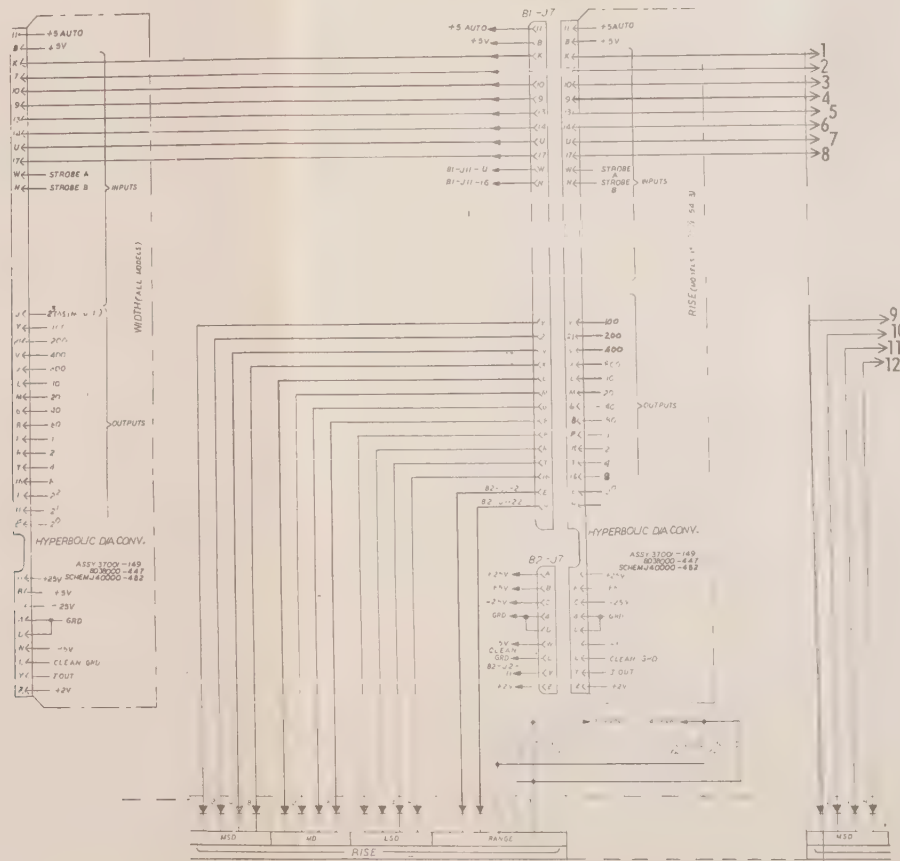
MODEL 153/154-1 and 3
HYPERBOLIC CONDUCTANCE D/A CONVERTER
SCHEMATIC SHEET 2 OF 2 #40000-550



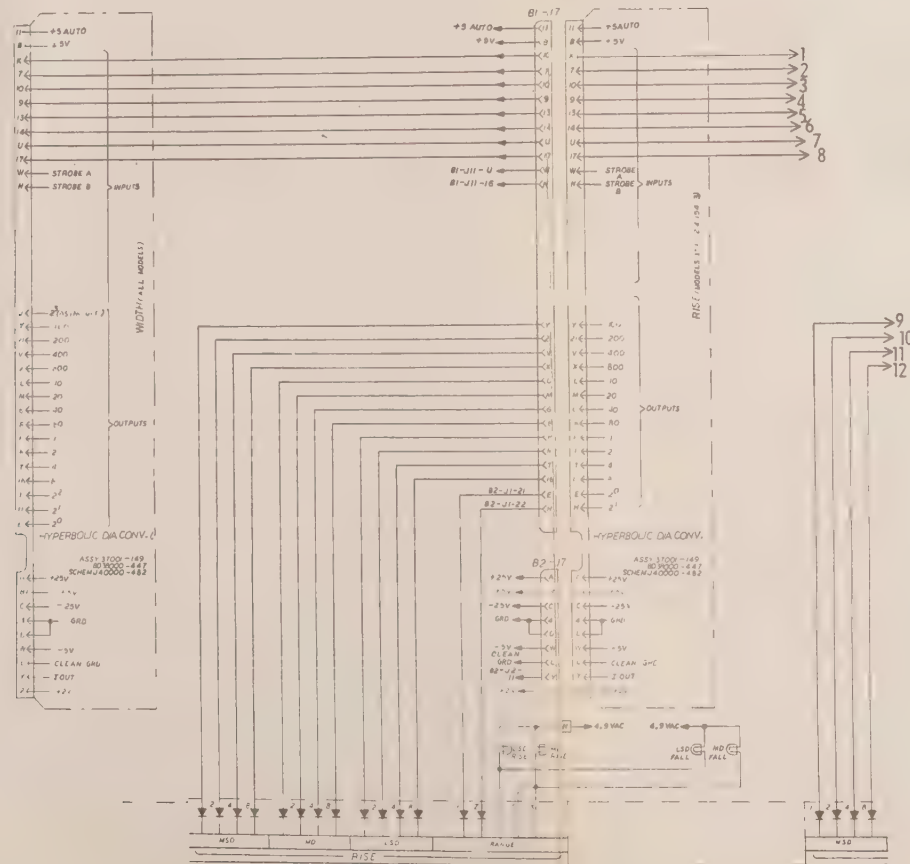
3. For positive true IC's 1-4 are SN7416
 2. For GND true IC's 1-4 are SN7417
 1. All capacitors are .022 μ F, 25V.
- NOTE: Unless otherwise specified



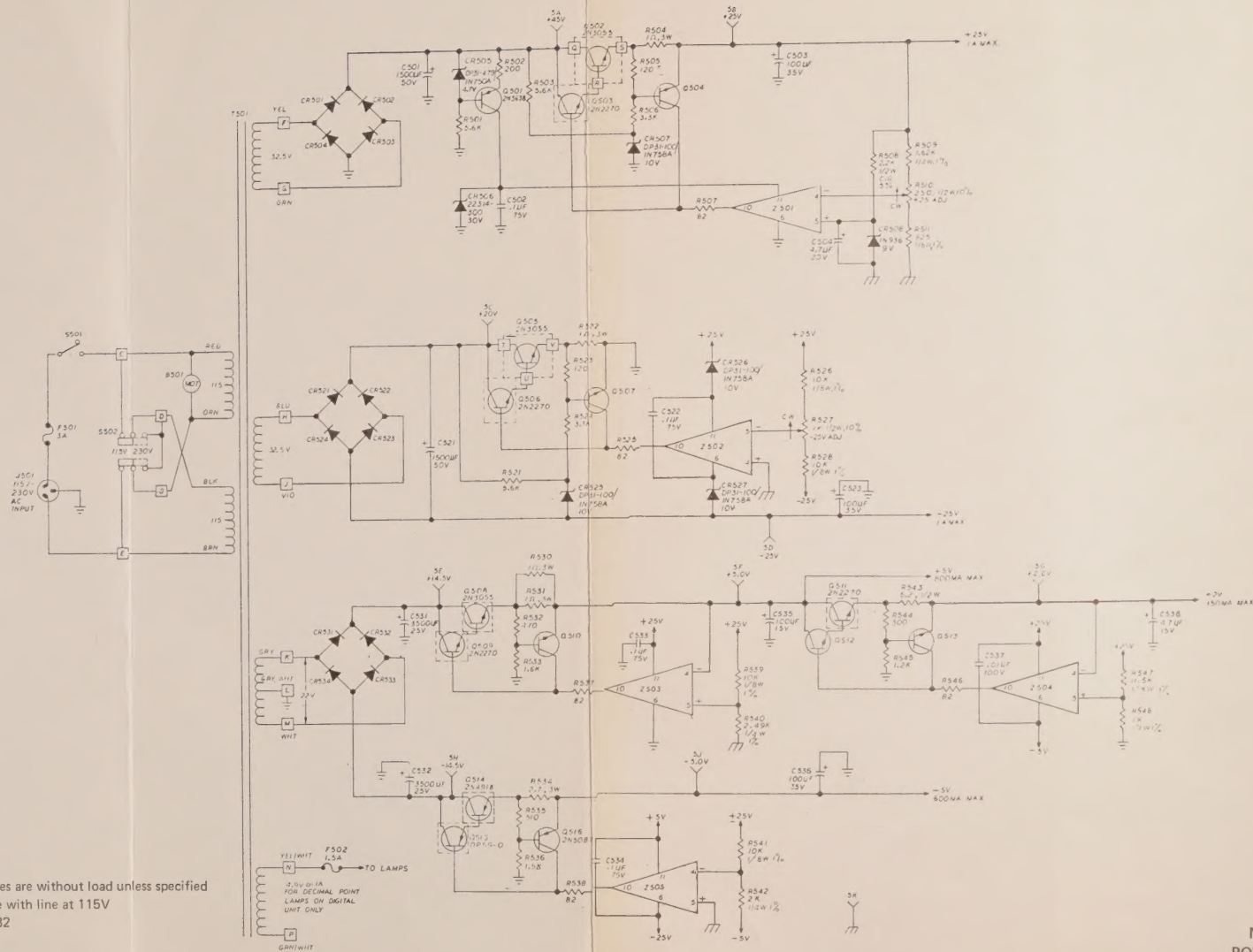
MODEL 153/154-1 and 3
 SERIAL TO PARALLEL CONVERTER
 SCHEMATIC SHEET 2 OF 2 #40000-483
 REV B



REV A



REV A



6. All transformer voltages are without load unless specified
 5. Test point voltages are with line at 115V
 4. All transistors are T282
 3. All IC's are UA741C
 2. All diodes are IRC20A
 1. Dotted lines around transistors indicate heatsink
- NOTE: Unless otherwise specified

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